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ABSTRACT

Developed as part of a competency-based curriculum in automotive mechanics which is usable by students at both the secondary and postsecondary levels, this learning package focuses on automotive electrical systems. It is the first unit to be published in a series of eight which will cover the eight subject areas on the national certification examination for auto mechanics. Following an introduction to the fundamentals of electricity and magnetism, this manual explains the identification, testing, and servicing of (1) automotive batteries, (2) the charging system, (3) the cranking circuit, (4) the ignition system, and (5) the electrical lighting and wiring of the body and chassis. Each unit contains lists of textbook references, of tools and materials needed, and of specific objectives, as well as a competency checklist for student use. Information sheets are provided with detailed diagrams, illustrations, and photographs. On the worksheets in each unit, students are asked to answer written questions or to demonstrate manually their achievement of the objectives. Tests are also provided at the conclusion of some of the units. (ELG)

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FINAL REPORT

PROJECT NUMBER: 01-012-150-318

SECONDARY-POSTSECONDARY CURRICULUM DEVELOPMENT IN AUTOMOTIVE MECHANICS

Automotive Electrical Competencies

Ronald Hoepner
Associate Supervisor, Trades and Industry

VTAE District One
620 West Clairemont Avenue
Eau Claire, WI 54701

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THE WISCONSIN BOARD OF VOCATIONAL, TECHNICAL AND ADULT EDUCATION
DIVISION OF COMMUNITY AND MANPOWER EDUCATION
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U.S. DEPARTMENT OF HEALTH,
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September 1, 1978

The activities reported herein were performed pursuant to a grant with the Wisconsin Board of Vocational, Technical and Adult Education, partially reimbursed from an allocation of federal funds from the U.S. Office of Education, Department of Health, Education and Welfare, under the authority of the Adult Education Act, P.L. 92-230, Section 309, as amended by P.L. 93-380. Points of view or opinions stated do not necessarily represent official State Board or U.S. Office of Education position or policy.

CE 018 774

The purpose of this project, as outlined in the initial proposal, was to begin the development of a competency-based curriculum in the automotive mechanics area. This curriculum was to be used by instructors in the CAPSTONE courses at the high school level as well as in the automotive mechanics program at District One Technical Institute. The proposal asserted that the achievement of this objective would enable all students coming into the automotive program at District One to have an equal opportunity to realize their occupational goal. Such opportunity would exist whether the student has had the CAPSTONE course or no opportunity whatsoever to receive previous training in this area.

In aiming at this objective, the project did accomplish the following:

1. Four 3-hour meetings were held during the course of the 1977-78 academic year prior to the summer workshop. The first of these meetings included the LVEC's within the district as well as seven CAPSTONE teachers and five automotive instructors at District One Technical Institute. The remaining three meetings involved the above-mentioned CAPSTONE teachers and District One instructors together with the project supervisor (see sample instructional package for names and locations of CAPSTONE teachers and names of District One instructors). During the course of these preliminary meetings, competency rating charts were developed as well as a format for the information sheets and worksheets contained in the instructional package. In addition, the eight major units of study for which instructional packages would be developed were identified. Further, the

major unit to be developed during the first workshop (automotive electrical) was identified.

2. A three-week workshop was conducted at the Technical Institute in which the participants worked for a period of 35 hours each week (June 12 through 30, 1978).
3. The completion of this workshop saw the beginning of the realization of the development of competency-based curriculum in automotive mechanics which is usable at both the secondary and postsecondary levels (see attached learning package). As indicated in number one above, automotive electrical was identified as the first of eight units to be so developed. These eight units coincide with the eight areas covered on the national certification examination. The electrical unit probably constitutes the most complex of all eight and probably would require the most time to develop. The next two units which have been identified for a subsequent workshop (please note proposal 01-012-150-319 submitted for fiscal year 1979) are engine repair and engine tuneup. It is anticipated that a workshop to develop the necessary articulated instructional packages will be developed through this project during the summer of 1979.
4. The instructional package in automotive electrical components will be piloted by the participating CAPSTONE teachers at the secondary level throughout the 1978-79 school year.
5. Several meetings involving the CAPSTONE teachers and District One Technical Institute automotive instructional staff will be held during the 1978-79 school year. Input will be obtained

through these meetings on the effectiveness of the instructional package which was developed through this project.

6. Considerable use was made of the appropriate V-TECS study, particularly during the meetings preceding the workshop and during the initial phases of the workshop.
7. The final financial report was forwarded to the state board office on July 31, 1978.

AUTOMOTIVE ARTICULATION PROJECT

Federal Number 01-012-150-318

Project Superviser: Ronald Hoepner, District 1 Technial Institute

Written and Compiled by:

Larry Cunningham	Spring Valley High School, Spring Valley
Mark Carlson	District 1 Technical Institute, Eau Claire
Dave Hoffelder	North High School, Eau Claire
Wayne Schroeder	District 1 Technical Institute, Eau Claire
Gene Fischer	North High School, Eau Claire
John Waters	Greenwood High School, Greenwood
Pete Vanish	District 1 Technical Institute, Eau Claire
Rex Hoover	Lake Holcombe High School, Holcombe
Vernon Knox	Chippewa Falls High School, Chippewa Falls
John Olson	District 1 Technical Institute, Eau Claire
Donald Anderson	Augusta High School, Augusta
Jerry Contney	District 1 Technical Institute, Eau Claire

ROUGH DRAFT

NOTE: This project was designed to improve communication and coordination between the area high schools and District 1 Technical Institute. It is designed for compatibility in the learning skills taught at both levels. It is meant to serve as a guide and follow-up between the high school and vocational school to insure uniform education with minimum duplication for the Automotive student. A limited number of copies are available at the cost of printing by contacting the superviser of the project.

This project is not intended for profit.

This material was developed pursuant to a grant or contract with the Wisconsin Board of Vocation, Technical and Adult Education, partially reimbursed from an allocation of Federal funds from the U.S. Office of Education, U.S. Department of Health, Education and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgement in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official State Board of U. S. Office of Education position or policy.

ACKNOWLEDGMENTS

This articulation project between area secondary schools and District One Technical Institute, could not have been successful without the use of diagrams, illustrations, and photographs from various manufacturer's training and service repair manuals.

We wish to thank the following companies for their permission and assistance:

American Motor Corporation
Applied Power
Champion Spark Plug Company
Chrysler Corporation
Delco-Remy
Ford Motor Company
General Motor Corporation
Sun Electric Corporation
Whitaker Cable Corporation

INDEX

A - Fundamentals of Electricity and Magnitism.

B - Automotive Batteries

C - The Charging System

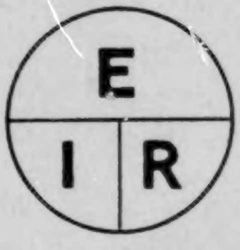
D - The Cranking Circuit

E - Ignition System

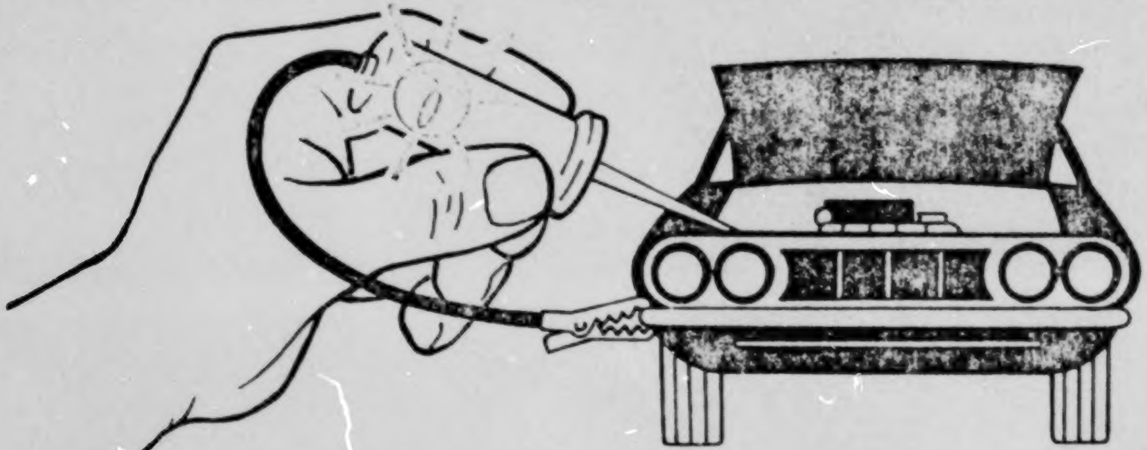
F - Body and Chassis

FUNDAMENTALS OF ELECTRICITY AND MAGNETISM

SIMPLE METHOD of COMPUTING OHM'S LAW



OHM'S LAW



Auto Mechanic's

Electrical Fundamentals

No. A - Introduction

This manual covers the Fundamentals of Electricity and Magnetism, and is basic to all of the other manuals. Because it is basic, it is probably the most important manual in the entire training series.

The subject of Fundamentals is the foundation upon which the study of electrical equipment is based. Whether the unit is a generator, an ignition coil, or a transistor regulator, the same basic principles contained in this manual apply equally will to all types of electrical equipment.

The student or service technician who wants to progress in his chosen field soon recognizes the paramount importance of a good knowledge of electrical fundamentals. This manual covers these fundamental principles of electricity and magnetism, and has been prepared for the student and technician who want a solid foundation upon which to build their knowledge of automotive-type electrical equipment.

REFERENCE

The texts chosen were selected because they are in current use by the instructors who compiled this manual. You should have a copy of at least one in your shop.

The text books are to be used as references for each exercise in this book. For each exercise you will find a number followed by page numbers. Look up the book number on this list and the page numbers will corresponds to the exercise you are working. For example if you find 5. 103-211 in the reference section you would check this reference list and find that book No. 5 is Auto Mechanics by H. E. Ellinger. In that book, pages 103-211 will apply to the exercise you are working.

	TEXT	AUTHOR	PUBLISHER
1.	Auto Service and Repair 1975	Stockel	Goodheart - Willcox
2.	Auto Mechanics Fundamentals 1974	Stockel	Goodheart - Willcox
3.	Motor Auto Engines and Electrical Systems 1975	Hearst Corporation	Motor
4.	Automotive Encyclopedia 1975	Tobotdt - Johnson	Goodheart - Willcox
5.	Auto Mechanics Second Edition	Ellinger	Prentice - Hall
6.	Automotive Mechanics	Crouse	McGraw - Hill
7.	The Auto Book	Crouse	McGraw - Hill
8.	Automotive Chassis And Accessory Circuits	Brezcha/Samuels	Prentice - Hall

Auto Mechanic's
Electrical Fundamentals
No. A- Index

A-1 -- Understanding Electron and Magnetic Theory

A-2 -- How To Use A Voltmeter

A-3 -- How To Use An Ammeter

A-4 -- How To Use An Ohmmeter

A-5 -- How To Identiry Electrical Components

    Symbols
    Circuit Protection Devices

A-6 -- How To Use Manuals For Test And Electrical Information

A-7 -- How To Use A Test Light And A Self Power Test Light

    Testing For Opens
    Testing For Shorts

A-8 -- How To Connect Wires

    Connections By Soldering
    Solderless Connectors

SCHOOL ______________________ STUDENT ______________________

INSTRUCTOR ______________________ YEAR GRAD ______________________

AUTOMOTIVE ELECTRICAL COMPETENCIES-FUNDAMENTALS

	COMPETENCY	JR	M	C	SR	M	C	VOC	M	C	IND	M	C
A-1	Understanding Electron and Magnetic Theory												
A-2	How to Use a Voltmeter												
A-3	How to Use an Ammeter												
A-4	How to Use an Ohmmeter												
A-5	Components, Symbols & Circuit Protection Devices I.D.												
A-6	How to Use Manuals For Test & Electrical Information												
A-7	How to Use a Test Lite and a Self-Powered Test Light												
A-8	How to Connect Wires												
9													
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21													

THIS COMPETENCY SHEET LISTS ALL THE SKILLS REQUIRED FOR THIS BOOK. THEY ARE LISTED IN A LOGICAL ORDER ALTHOUGH THERE IS NO FIXED SEQUENCE FOR COMPLETING THE EXERCISES. EACH HEADING HAS A COLUMN TO ITS RIGHT WITH SPACES TO ALLOW GRADING AFTER YOU COMPLETE THAT EXERCISE. WE HAVE TAKEN INTO ACCOUNT THAT NOT EVERY EXERCISE WILL BE COMPLETED THE FIRST YEAR. THEREFORE, WE HAVE SPOTS FOR JUNIOR, SENIOR, VOCATIONAL AND INDUSTRY. AS YOU COMPLETE A PARTICULAR COMPETENCY, (OR TASK) YOU WILL BE GRADED ACCORDING TO THE SCALE AT THE BOTTOM OF THIS SHEET. ALSO, IF THERE ARE ANY MATH OR COMMUNICATION SKILLS REQUIRED THEY CAN ALSO BE GRADED USING THE CODE N, 1, 2, OR 3. THE DATE OF COMPLETION WILL BE ENTERED UNDER THE APPROPRIATE YEAR AND COMPETENCY. YOU WILL HAVE THE OPPORTUNITY TO UPGRADE ANY ONE OF THESE SKILLS AT ANY TIME AFTER YOU FIRST COMPLETE THE TASK AND HAVE THE NEW RATING ENTERED ON THIS SHEET.

RATING SCALE

N = No opportunity to perform
1 = Completed exercise with close supervision
2 = Completed exercise with little supervision
3 = Completed exercise without supervision

M = Math
C = Communications

SCHOOL ____________________ STUDENT ____________________

INSTRUCTOR ____________________ YEAR GRAD ____________________

AUTOMOTIVE ELECTRICAL COMPETENCIES-FUNDAMENTALS

	COMPETENCY	JR	M	C	SR	M	C	VOC	M	C	IND	M	C
A-1	Understanding Electron and Magnetic Theory												
A-2	How to Use a Voltment												
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RATING SCALE

N = No opportunity to perform
1 = Completed exercise with close supervision
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3 = Completed exercise without supervision

M = Math
C = Communications

X

AUTO MECHANICS

Electrical Competencies

No. A-1 ELECTRON THEORY AND MAGNETISM

OBJECTIVE:

After completion of this exercise, the student will understand electron theory and magnetism, in addition, the student will be able to identify circuit types.

EXPLANATION:

1. Pass written test with ____ ____% accuracy.
2. "Hook-up" 3 basic circuits with resistance units to instructor's satisfaction.

MATERIALS NEEDED:

Electrical wire, minimum of four resistances, power source (low voltage) switch.

TOOLS NEEDED:

wire cutters- needlenose pliers- screwdriver- wire stripper

References	Do
#1. --	#1. Read the assigned reference.
#2. p. 365-372	#2. Read the information sheets.
#3. p. 423-441	#3. Do electrical circuits worksheets.
#4. p. 335-344	#4. Obtain instructors approval.
#5. p. 149-151	#5. Take written test.
#6. p. 242-246	#6. Check with instructor.
#7. p. 215-222	
#8. p. 1-17	

Electrical Competencies- Electrical Fundamentals

No. A -1 Electron Theory and Magnetism

Information Sheet # 1

Battery- A group of 2 or more cells connected together to produce an electric current. It converts chemical energy into electrical energy.

Circuit- The complete path provided for current flow. This complete path is called a closed circuit and when its continuity is broken, an open circuit.

Series circuit- A circuit which provides only one path for the current to flow.

Parallel circuit- A circuit which provides more than one path for current to flow. This arrangemant provides full electrical potential (voltage) to all portions of the circuit.

Conductor- A wire or other metallic object capable of transmitting electricity.

Current- The movement of electricity comparable to the flow of a stream of water. The movement of free electrons along a conductor.

Cycle- A series of events that occur over and over in a given sequence. In a battery, the process of constant discharging and charging.

Draw- (amperage)- The quantity of current used to operate an electrical device.

Drop (voltage)- The net difference in electrical pressure when measured across a resistance.

Electricity- The movement of electrons from one body of matter to another.

Electromotive force- That which moves or tends to move electricity. Caused by a difference in electrical potential

Electron- The negatively charged particles of an atom which revolve around the nucleus.

Electron Theory- States that all matter is made up of atoms which contain electrons, some of which are free to move from one atom to another.

Ground- The connection made in grounding a circuit. In automotive use, the result of attaching one battery cable to the body of frame which is used as a path for completing a circuit in lieu of a direct wire.

Ohm- The practical unit for measuring electrical resistance.

Resistance- The opposition offered by a substance of body to the free flow of an electic current ,measured in ohms.

Short circuit- Often used to describe an unintentional grounding of a circuit. More accurately, a path created when an insulation breakdown occurs.

Volt- A practical unit for measuring current pressure in a circuit; that force, when steadily applied to a conductor with a resistance of one ohm will produce a current flow of one ampere.

Watt- The unit for measuring electrical energy or "work". One watt is product of one ampere multiplied by one volt.

Ampere- The practical unit of measuring the flow of an electric current. The amount of current produced by one volt acting through a resistance of one ohm.

Circuit breaker- A device other than a fuse, for interrupting a circuit under infrequent abnormal conditions.

Electromotive force- That which moves, or tends to move, electricity; the amount of energy derived from an electrical source per unit quantity of electricity passing through the source, measured in volts.

Farad- The unit of electrical capacity; the capacity of a condenser which, charged with one coulomb, gives a difference of potential of one volt.

Generator- A machine by which mechanical energy is changed into electrical energy.

Insulator- A nonconducting substance of body, as porcelain or glass, used in insulating wires, etc.

Megohm- 1,000,000 ohms

Microfarad- 1/1,000,000 farad

Milliampere- 1/1,000 ampere

Millivolt- .001 volt

Rectifier- An electrical device for changing alternating current into direct current.

Rheostat- A resistor for regulating a current by means of variable resistance.

A C Current - The direction of current flow is changing direction, in one direction then another.

Electrical Competencies- Electrical Fundamentals

No. A - 1 Electron Theory and Magnetism

Worksheet # 1

Name ______________________ Date __________ Grade ______________

1. A proton has a ________________ charge.

2. A neutron has a ________________ charge

3. An electron has a ________________ charge.

4. ________________ is the mass movement of electrons through a conductor.

5. ________________ is the measurement of the quantity of electron flow.

6. A ________________ is any material that allows electrons to flow through it freely.

7. An ________________ is any material that does not allow electrons to flow through it freely.

8. The pressure in an electrical circuit is called ________________.

9. ________________ is opposition to the flow of electrons in an electrical circuit.

10. Like charges will ________________ each other.

11. Unlike charges will ________________each other.

12. The type of circuit that has more than one path for the flow of electrons is called a ______________circuit.

13. The type of circuit that has more than one path for the flow of electrons in one part of the circuit and only one path in another part is called a ____________________circuit.

14. The type of circuit that has only one path for the flow of electrons is called a ____________________circuit.

15-19. List five examples of materials used for electrical conductors.

15. ______________ 16. ______________ 17.______________

18. ______________ 19. ______________

20-24. List five examples of materials used for electrical insulators.

20. ______________ 21. ______________ 22. ______________

23. ______________ 24. ______________

25-27. List three items that determine the resistance of a conductor.

25. ______________ 26. ______________ 27. ______________

28. What is the name of the area surrounding a magnet?

29. Which of the following are magnetic substances?

a. Iron	c. Nickel
b. Brass	d. Lead

30. The magnetic field of force surrounding an electrical conductor is in what direction?
    a. Parallel to the conductor.
    b. At right angles to the conductor.

31. If you insert an iron core in a coil of wire carrying current, will the field be:
    a. Strengthened.
    b. Weakened.

32. State Ohm's Law.

33. What produces magnetism?

34. What is the difference between an electro magnet and a permanent magnet?

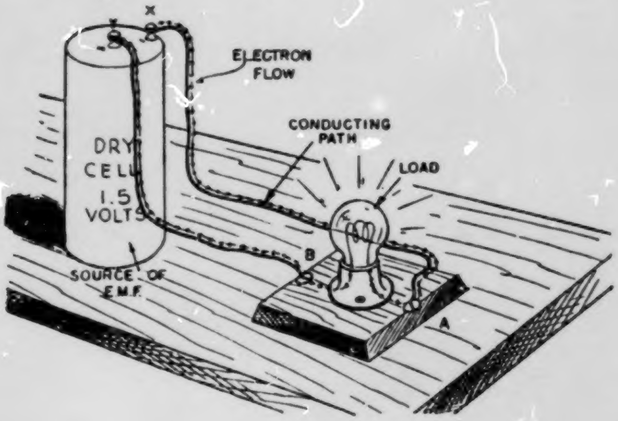
35. Does a magnet have a definite polarity?

36. Like magnetic poles (north and north, for instance):
    a. attract each other.
    b. cancel out.
    c. repel each other.

No. A -1 Electron Theory and Magnetism

Worksheet #2

Name ______________________ Date ____________ Grade ____________

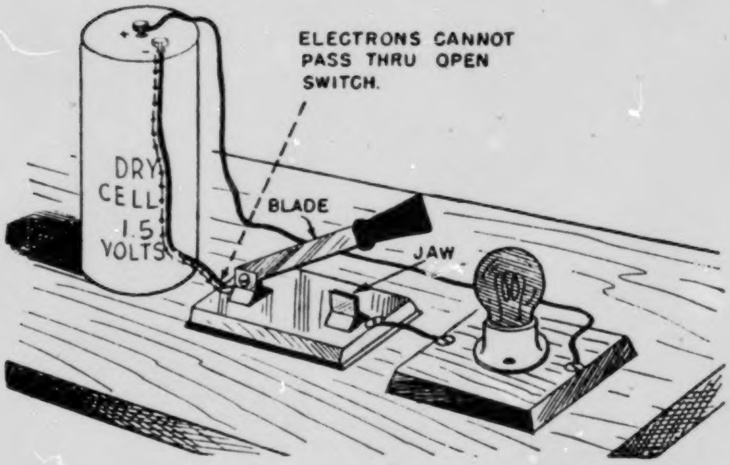

x
ELECTRON FLOW
CONDUCTING PATH
LOAD
DRY CELL 1.5 VOLTS
B
SOURCE OF E.M.F.
A

A complete electric circuit consists of a source of emf, a conducting path, and a load. The circuit is said to be closed when the current can flow from the source of emf, through the load, and return to the source.

1. Construct a series circuit as shown in the above picture.

After completing this portion of the worksheet, have your instruct check you work.

Instructor initials *__________

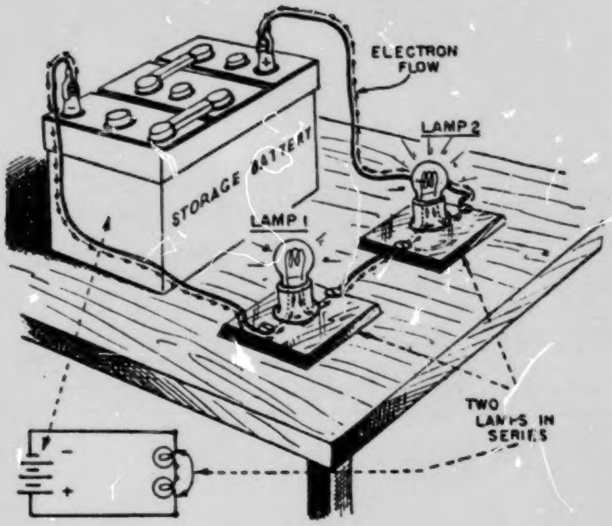

ELECTRONS CANNOT PASS THRU OPEN SWITCH.
DRY CELL 1.5 VOLTS
BLADE
JAW

The circuit is broken when the switch is open. No current will flow through an open circuit.

2. Construct a series circuit as shown in the above picture.

After completing this portion of the worksheet, have you instructor check your work.

Instructor initials *__________

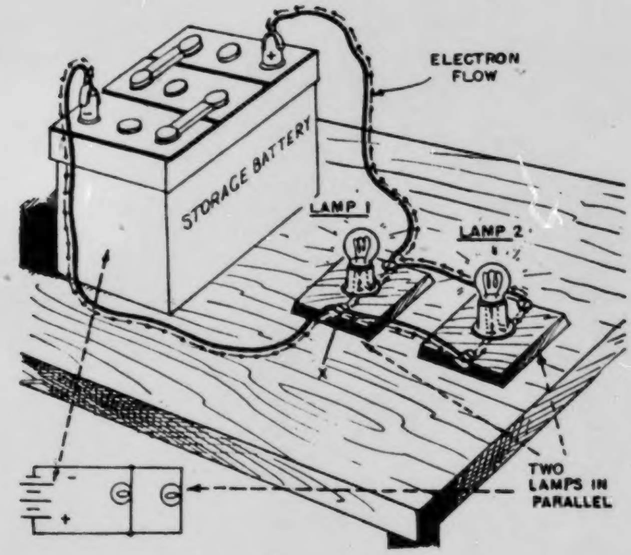

ELECTRON FLOW
LAMP 2
STORAGE BATTERY
LAMP 1
TWO LAMPS IN SERIES
-
+

A series circuit. The current flows from the source of emf, through the first lamp, and then through the second before returning to the source. Together the lamps form a load. Removing one lamp opens the circuit, causing the other lamp to go out.

3. Construct a series circuit as shown in the above picture.

After completing this portion of the worksheet, have your instructor check your work.

Instructor initials *__________

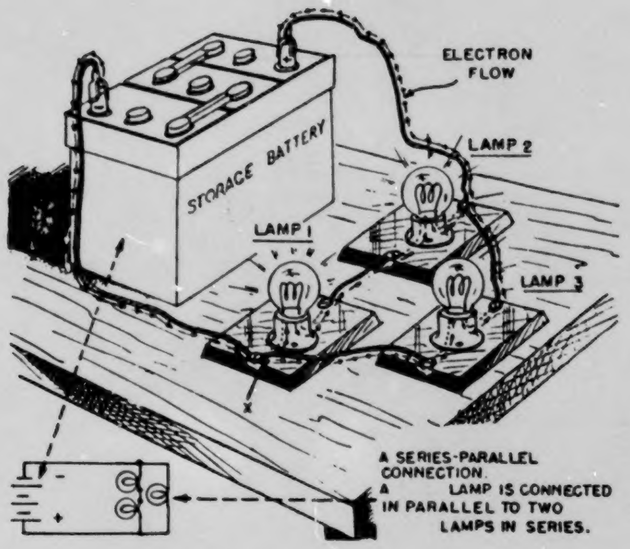

ELECTRON FLOW
STORAGE BATTERY
LAMP 1
LAMP 2
TWO LAMPS IN PARALLEL
-
+

A parallel circuit. The current leaving the source divides, part going through one lamp and part through the other. Each lamp is a branch of the parallel circuit. Removing one lamp does not cause the other to go out since, in a parallel-circuit, opening one branch does not prevent the current from flowing through the other.

4. Construct a parallel circuit as shown in the above picture.

After completing this portion of the worksheet, have your instructor check your work.

Instructor initials *__________

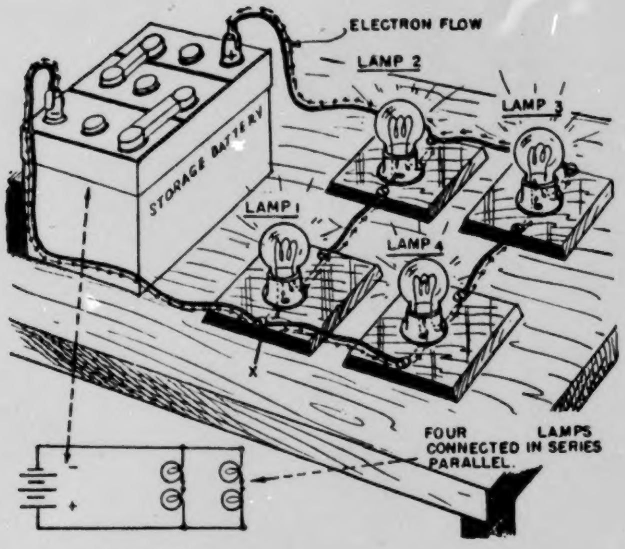

ELECTRON FLOW
LAMP 2
STORAGE BATTERY
LAMP 1
LAMP 3
X
A SERIES-PARALLEL CONNECTION.
A LAMP IS CONNECTED IN PARALLEL TO TWO LAMPS IN SERIES.
-
+

A series-parallel circuit. Lamps 1 and 2 are in series but form one branch of the parallel circuit. Lamp 3 is the second branch.

5. Construct a series-parallel circuit as shown in the above picture.

After completing this portion of the worksheet, have your instructor check your work.

Instructor initials *__________


ELECTRON FLOW
LAMP 2
LAMP 3
STORAGE BATTERY
LAMP 1
LAMP 4
X
FOUR LAMPS CONNECTED IN SERIES PARALLEL.
-
+

Each branch of the parallel circuit contains two lamps connected in series.

6. Construct a series-parallel circuit as shown in the above pictu

After completing this portion of the worksheet, have your instructor check your work.

Instructor initials *__________

Electrical Competencies- Electrical Fundamentals

No. A - 1 Electron and Magnetic Theory

Test # 1

Name ______________________________ Date __________ Grade ____________

Electrical Fundamentals Test- Final

Instructions: Select the one best answer for each question.

1. Protons have a ____________charge.
   a. negative
   b. positive
   c. neutral
   d. none of the above
   e. all of the above

2. Neutrons have a ______________charge.
   a. negative
   b. positive
   c. neutral
   d. none of the above
   e. all of the above

3. Electrons have a ______________charge.
   a. negative
   b. positive
   c. neutral
   d. none of the above
   e. all of the above

4. ______________________is the movement of electrons through a conductor.
   a. electromotive force
   b. intensity
   c. resistance
   d. electricity
   e. none of the above

5. ______________________is the quantity of electron flow.
   a. electromotive force
   b. intensity
   c. resistance
   d. electricity
   e. none of the above

6. ______________________is the measure of electron flos.
   a. electromotive force
   b. intensity
   c. resistance
   d. electricity
   e. none of the above

7. The pressure in an electric circuit is measured in units called:
   a. amps
   b. volts
   c. ohms
   d. watts
   e. none of the above

8. The volume of electrical flow in a circuit is measured in units called____________.
   a. amps
   b. volts
   c. ohms
   d. watts
   e. none of the above

9. The opposition to the flow of electrons in an electrical circuit is measured in________________________.
   a. amps
   b. volts
   c. ohms
   d. watts
   e. none of the above

10. Materials which have a complete outer electron ring are known as _____________.
   a. conductors
   b. insulators
   c. neutrons
   d. stable material
   e. all of the above

11. Materials which have one or more free electrons in the outer electron ring are known as __________________.
   a. conductors
   b. insulators
   c. neutrons
   d. stable material
   e. all of the above

12. If two magnetic north poles are brought together they will __________each other.
   a. repel
   b. attract
   c. cancel
   d. have no effect on each other
   e. none of the above.

13. If two magnetic south poles are brought together they will ___________each other.
   a. repel
   b. attract
   c. cancel
   d. have no effect on each other
   e. none of the above

14. If north and south magnetic poles are brought together they will ______each other.
   a. repel
   b. attract
   c. cancel
   d. have no effect on each other
   e. none of the above

15. The type of circuit that has more than one path for the flow of electrons in one part of the circuit and only one path in another part is called a ________circuit.
   a. series
   b. parallel
   c. perpendicular
   d. series-parallel
   e. none of the above

16. The type of circuit that has only one path for the flow of electrons is called a _________________ circuit.

17. The type of circuit that has more than one path for the flow of electrons is called a _________________ circuit.

18. Which of the following is an example of a conductor?
a. copper
b. aluminum
c. steel
d. brass
e. all of the above

19. Which of the following is an example of an insulator?
a. rubber
b. glass
c. most plastics
d. iron
e. answers a, b, and c

20. The resistance of a conductor is determined by:
a. its length
b. its size or cross sectional area
c. the material made of
d. all of the above
e. none of the above

21. The area surrounding a magnet is called a(n):
a. electrical circuit
b. magnetic field
c. electromotive force
d. electron theory
e. none of the above

22. Ohms Law may be written:
a. $I= \frac{E}{R}$
b. $E= I \times R$
c. answers a, b, and e
d. $R= I \times E$
e. $R= \frac{E}{I}$

23. Lines of force of a magnet always:
a. leave the S pole and enter the N pole
b. leave the N pole and enter the S pole
c. leave the E pole and enter the W pole
d. leave the W pole and enter the E pole

24. Every magnet has an:
a. N and S pole
b. E and W pole
c. W and N pole
d. answers a and b
e. none of the above

25. Which of the following can be magnetized?
a. Lead
b. Iron
c. Brass
d. Nickel
e. answers a, b, and d

AUTO MECHANICS

Electrical Competencies - Electrical Fundamentals

No. A-2 How to Use a Voltmeter

OBJECTIVE:

After completion of this exercise, the student will be able to use a voltmeter correctly.

EXPLANATION:

1. Pass written test with a minumum of _______% accuracy.
2. Demonstrate to the instructor how to zero set the voltmeter, select proper range, measure the voltage, select and read the proper scale.

MATERIALS NEEDED:

D.C. power source (40 v. or less)
Switch
Two light bulbs
Necessary wiring

TOOLS NEEDED:

Voltmeter

References	Do
#1. --	#1. Read assigned reference material
#2. p. 368	#2. Study information sheets
#3. p. 452-453	#3. Take written test
#4. p. 469-470	#4. Instructor sign credit sheet
#5. --	#5. Demonstrate proper voltmeter
#6. --	#6. Instructor sign credit sheet
#7. p. 218	#7. Return tools and materials
#8. p. 104-106	

Electrical Competencies- Electrical Fundamentals

No. A-2 How to Use a Voltmeter

Information Sheet # 1

What Is Voltage?

Voltage is an electrical property that is best defined as the strength or force of the electricity. Or we might say it is the amount of push that's available to make electricity flow in a circuit. You could compare it to pressure in a hydraulic or air system.

It's Measured in Volts

The unit of measure for electricity is the volt. We're accustomed to a 12-volt power source in today's automobile, but most of us can remember when 6-volt systems were common. The 12-volt system has twice the "push". If you connect a modern headlamp to a 6-volt battery, it will glow dimly, because it doesn't get enough voltage to make it do its job.

The Voltmeter

The test instrument used to measure voltage is the voltmeter. A typical automotive voltmeter will have two scales and three scale selector positions as shown in the illustration.

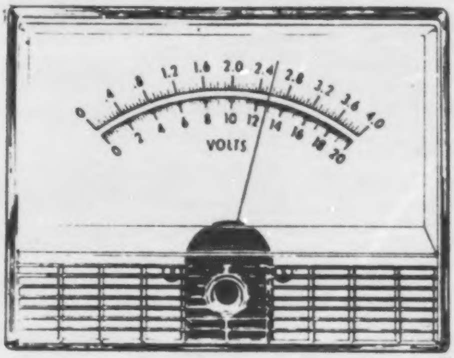
- In the 4V position, read the voltage directly on the zero to 4 volt scale.
- In the 20V position, read the voltage directly on the zero to 20 volt scale.
- In the 40 V position, multiply the 4 volt scale reading by 10.

Watch the Polarity!

The two test leads to the meter are marked positive (+) and negative (-). Usually they are also color coded. The negative lead is black, and the positive lead is red or some other color than black. Always connect the negative lead to the ground side of the circuit, and the positive lead to the hot side. If you get them mixed, the meter will read negative, and may be damaged.

Voltage Drops Add Up

It's a basic law of electrical circuits, that, where resistances are connected in series, the voltage drops add up to the total available voltage at the source. Also, each voltage drop will be proportional to the resistance of the component the electricity flows through.



Typical Voltmeter

TEST METERS

The use of test meters is an invaluable and essential aid in diagnosing troubles in an electrical circuit. If values of voltage, current and resistance are not measured with suitable test meters, only a guess can be made as to what type of defect exists in the circuit.

Voltmeters

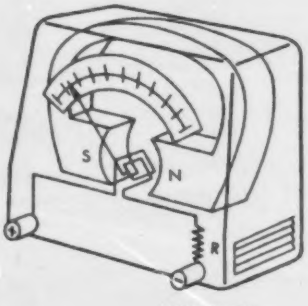
Most voltmeters are of the moving coil type which consists of a permanent horseshoe magnet and a movable coil. Current flowing through the movable coil reacts with the permanent magnetic field, causing the coil to turn against a slight spring tension. The relative movement of the coil is in direct proportion to the amount of current flowing in the coil, which in turn is proportional to the amount of voltage to which the voltmeter is connected. A pointer attached to the coil moves across a scale calibrated in volts to indicate directly the value of the voltage being measured.

Because the moving coil is very small and sensitive, the current through the coil must be limited to safe values. To accomplish this, voltmeters are constructed with an internal resistor in series with the coil to limit the current to a safe value. The voltmeter scale is calibrated accordingly in order to indicate the true voltage.

The voltmeter resistance is often printed on the face of the meter, and usually is specified in ohms per volt. If the voltmeter resistance is 1,000 ohms per volt, and the 20-volt scale on the meter is being used, the voltmeter internal resistance is 1,000 x 20 = 20,000 ohms.

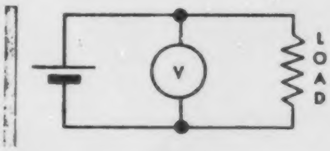
Voltmeters having a choice of scales have a selector knob to insert different resistor values in series with the moving coil. The selector knob would choose an internal resistance of 10,000 ohms for a 10-volt scale, thus adhering to the 1,000 ohms per volt specification. In general, the higher the ohms per volt rating the more sensitive the voltmeter.

Voltmeters are connected across (in parallel with) the voltage to be measured. Since the voltmeter has a high resistance, adding this component to the circuit will change the total circuit current very little, and voltage reading obtained indicates the true voltage present without the meter in the circuit.



VOLTMETER

VOLTMETERS
CONNECTED
IN PARALLEL



The voltmeter measures the amount of electric pressure in a circuit. The voltmeter is used to measure the voltage in any battery circuit or the primary ignition circuit of a vehicle.

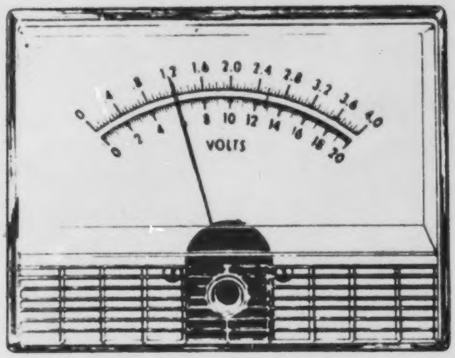
Examples of useful voltage measurements are cranking voltage, the battery's voltage while cranking the engine, charging voltage, the voltage at which the charging system operates, and applied voltage, the amount of voltage put into a circuit or accessory. In addition, the voltmeter may be used to measure circuit resistance, the amount of voltage lost because of excessive resistance in a circuit.

The voltmeter uses two leads, the Red clip is positive (+),the Black clip is negative (-).

The VOLT selector knob is used to select the scale or range of voltage being read on the multiple-scale meter, or the positive lead is plugged into the jack for the range desired.

The voltmeter is always connected in parallel with the power source.

The volt selector knob is used to select the range needed. Always select a range which is higher than the highest possible voltage which might be encountered. The voltage scale always reads from left to right. On the meter face shown, the ranges may be read as: zero to four volts for the low scale, and zero to forty volts for the high scale. The lower scale may be read as zero to twenty volts or zero to two-hundred volts depending on the ranges on the meter and the one you select.



Example-- On the meter face shown, assume the meter is set on the 4 volt scale; the meter scale would be read directly and the reading would be 1.2 volts. If the range selector were set on the 40 volt scale the meter would be read as 1.2 x 10 or 12 volts. If the meter shown were set for the 20 volt range, the reading would be 6 volts. If this meter had a 200 volt scale the reading would be a 6 x 10 or 60 volts. A meter might be found which also had a 2,000 volt scale, in which case, the reading becomes 6 x 100 or 600 volts.

On some occasions, a meter is found where the meter reading must be reduced. Example-- If the meter, the face of which is shown, had a 2 volt scale, the bottom or 20 volt scale would then be read. The reading would then be 6/10 or .6 volts.

Available Voltage and Voltage Drop

In electrical diagnosis, we frequently use the voltmeter to measure voltage drop. Voltage drop is a reduction or "using up" of the voltage to push electricity through a resistance. It can be compared to the pressure drop when water flows through a metering valve, or carburetor intake air flowing through the venturi into the manifold. We can best demonstrate this on a heater blower circuit, where we use resistors for a deliberate voltage drop.

Measuring Voltage Drop Directly

We have just seen how to compute voltage drop by subtracting available voltage at one point from available voltage at a preceding point. It is also possible to read voltage drop directly on the meter. Simply connect the meter across the component or segment of the circuit.

Be sure to connect the positive lead to the battery side and the negative lead to the ground side.

the circuit not operating, no-load voltage will be the same anywhere in the hot circuit, no matter how much resistance is present.

So Don't Forget

The circuit must be operating (under load) to:
- Read voltage drop directly
- Read available voltage in order to compute voltage drop.

If it's not under load, the voltage won't drop.

Remember These Facts About Voltage Drop

1. Voltage drop occurs when electricity flows through a resistance.
2. The resistance can be:
    - the load
    - a resistor used for speed control of a motor or brightness control of a lamp
    - a poor connection in either the hot or ground circuit
3. Measure voltage drop directly by connecting the voltmeter across the component with the circuit operating.

MAXIMUM ALLOWABLE VOLTAGE DROP UNDER LOAD

When you are checking for high resistance in a circuit, it's a good idea to start right at the battery. There may be more than one high resistance point in the circuit, and they have a cumulative effect. You can leave the voltmeter positive lead connected to the positive terminal and move the negative lead to various test points in the circuit until you isolate the problem.

The voltage drop should not be more than listed in the table.

BATTERY TO . . .	MAX. VOLTS
Fuse panel	.7
Ignition switch	.7
Headlight switch	.7
Load	1.3
Ignition coil Battery terminal (ignition switch in start position)	.5 (critical)

Electrical Competencies- Electrical Fundamentals

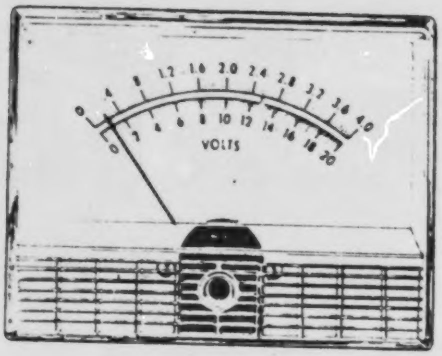
No. A - 2 How to Read a Voltmeter

Worksheet # 1

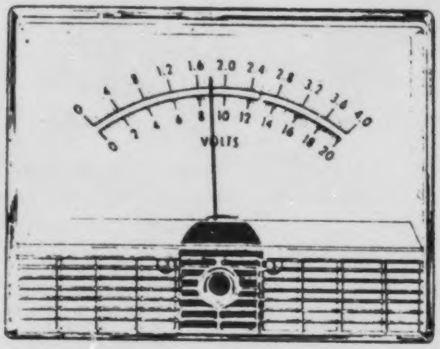
Name ______________________________ **Date** ____________________ **Grade** ______________

Directions;

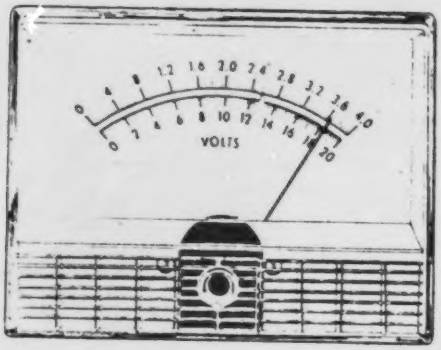
In the spaces provided by the corresponding scale selector position, record the indicated voltmeter readings.


0 .4 .8 1.2 1.6 2.0 2.4 2.8 3.2 3.6 4.0
0 2 4 6 8 10 12 14 16 18 20
VOLTS

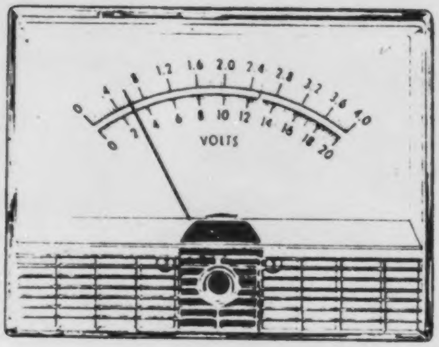
1. 4 volt scale _____v,
2. 20 volt scale _____v.
3. 40 volt scale _____v.


0 .4 .8 1.2 1.6 2.0 2.4 2.8 3.2 3.6 4.0
0 2 4 6 8 10 12 14 16 18 20
VOLTS

4. 4 volt scale _____v.
5. 20 volt scale _____v.
6. 40 volt scale _____v.


0 .4 .8 1.2 1.6 2.0 2.4 2.8 3.2 3.6 4.0
0 2 4 6 8 10 12 14 16 18 20
VOLTS

7. 4 volt scale _____v.
8. 20 volt scale _____v.
9. 40 volt scale _____v.

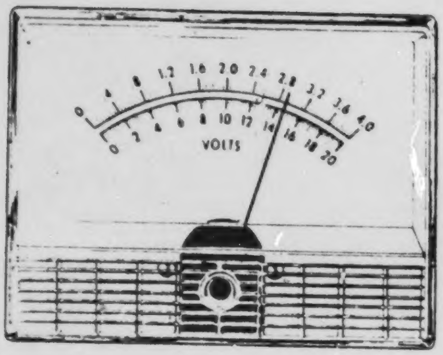

0 .4 .8 1.2 1.6 2.0 2.4 2.8 3.2 3.6 4.0
0 2 4 6 8 10 12 14 16 18 20
VOLTS

10. 4 volt scale _____v.
11. 20 volt scale _____v.
12. 40 volt scale _____v.

No. A - 2 How to Read a Voltmeter

Worksheet # 1

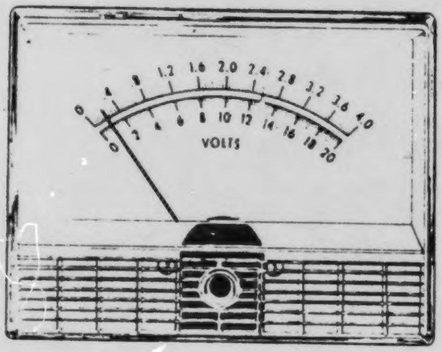
Page 2.


0 .4 .8 1.2 1.6 2.0 2.4 2.8 3.2 3.6 4.0
0 2 4 6 8 10 12 14 16 18 20
VOLTS

13. 4 volt scale _____v.

14. 20 volt scale _____v.

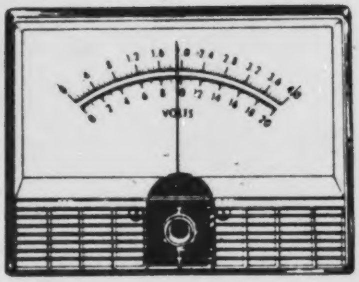
15. 40 volt scale _____v.


0 .4 .8 1.2 1.6 2.0 2.4 2.8 3.2 3.6 4.0
0 2 4 6 8 10 12 14 16 18 20
VOLTS

16. 4 volt scale _____v.

17. 20 volt scale _____v.

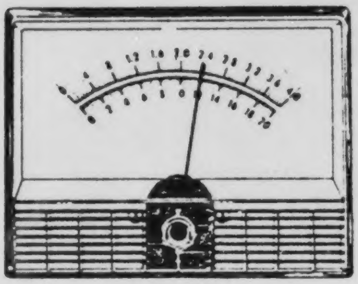
18. 40 volt scale _____v.


0 .4 .8 1.2 1.6 2.0 2.4 2.8 3.2 3.6 4.0
0 2 4 6 8 10 12 14 16 18 20
VOLTS

19. 4 volt scale _____v.

20. 20 volt scale _____v.

21. 40 volt scale _____v.


0 .4 .8 1.2 1.6 2.0 2.4 2.8 3.2 3.6 4.0
0 2 4 6 8 10 12 14 16 18 20

22. 4 volt scale _____v.

23. 20 volt scale _____v.

24. 40 volt scale _____v.

Instructor's initials * ____________

Electrical Competencies- Electrical Fundamentals

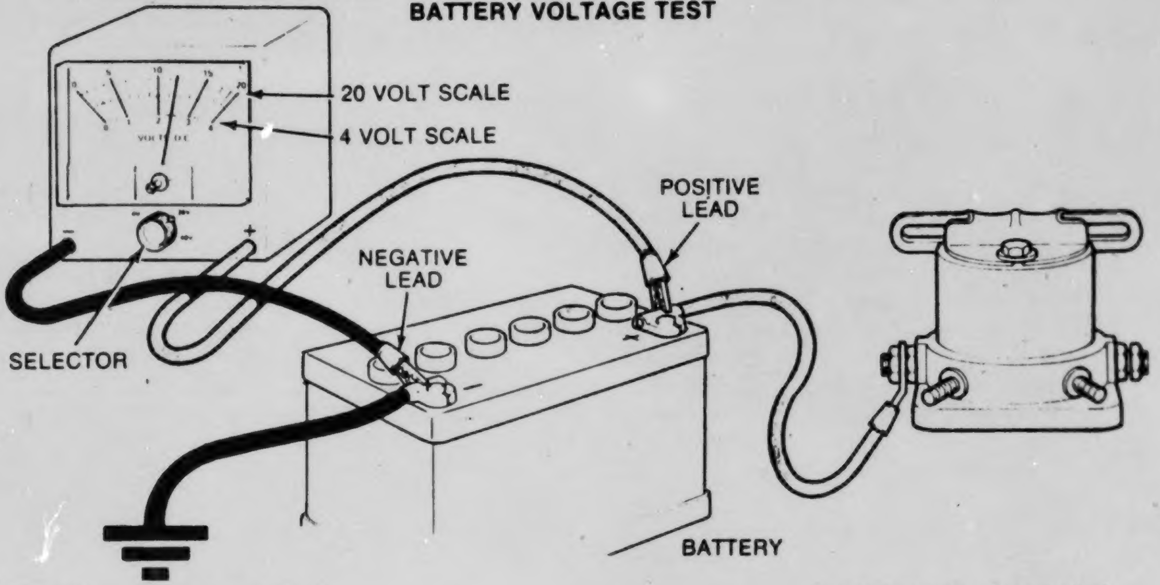
No. A-2 How to Use a Voltmeter

Worksheet #2

Name ______________________ Date ____________________ Grade ______________

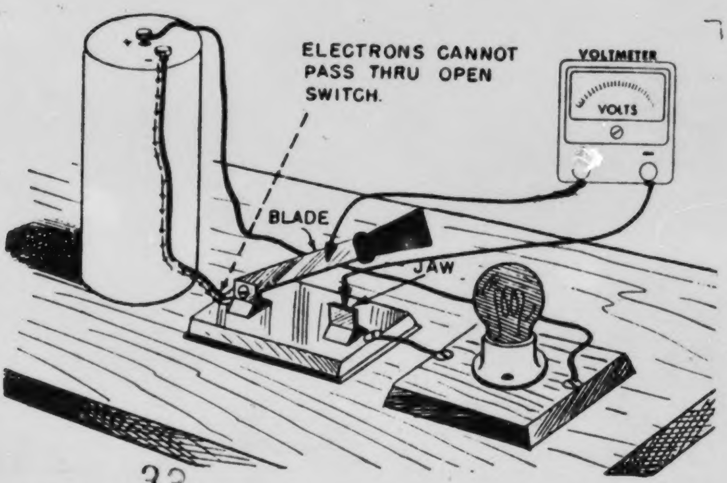
1. Battery Voltage Check
The illustration shows the meter connected to read battery voltage. The selector is set for the 20 volt scale, and the meter is reading just over 12 volts. Less than 11.5 volts at the battery is not enough to operate the electrical systems effectively.

BATTERY VOLTAGE TEST


20 VOLT SCALE
4 VOLT SCALE
POSITIVE LEAD
NEGATIVE LEAD
SELECTOR
BATTERY

Reading across battery ____________________ Instructors initials*__________

2. Potential Voltage
Voltage across a switch. The circuit is broken when the switch is open. No current will flow through an open circuit. However, voltage potential exists across the switch. Check this voltage potential by connecting your voltmeter at points A and B in the picture. What is the voltage potential with the switch open? What is the potential with the switch closed? Why is their no potential when the switch is closed?


ELECTRONS CANNOT PASS THRU OPEN SWITCH.
VOLTMETER
VOLTS
BLADE
JAW

A to B voltage switch open ______________________________volts
A to B voltage switch closed ______________________________volts

Why does the voltage change when the switch is closed? ______________________________

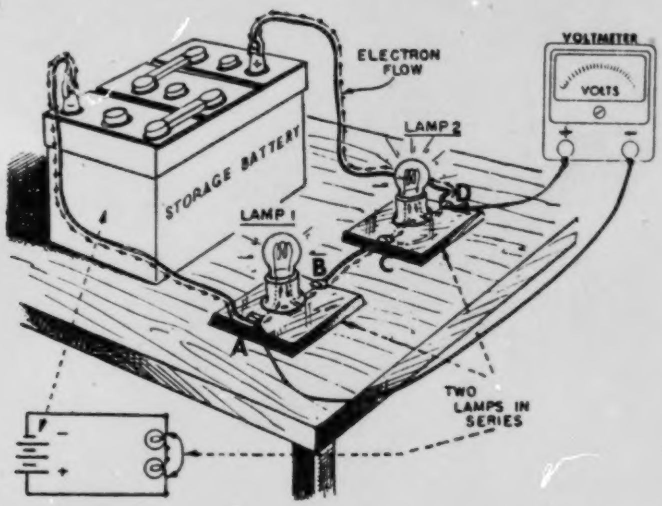
____

____

Instructor's Initials ________

3. Voltage Drop In A Series Circuit

Connect your voltmeter from A to D. Notice the voltage applied to the series circuit is that of the battery output. Now check the voltage A to B, and C to D. Notice the voltage drop across each unit is equal to one half the applied voltage. (Use bulbs of equal size and voltage). Now substitute a six volt bulb for "Lamp On" in the circuit. Now take another voltage reading from A to B and C to D. Notice now that the big voltage drop occurs across the 12V bulb with only a small drop occuring across to 6V bulb.



A to D voltage __________volts
A to B voltage __________volts
C to D voltage __________volts
With 6 volt bulb in one socket:
A to B voltage __________volts
C to D voltage __________volts

Why is there a voltage difference when one 6 volt bulb is used?

____

____

____

Instructor's Initials ________

AUTO MECHANICS

Electrical Competencies - Electrical Fundamentals

No. A-3 How To Use An Ammeter

OBJECTIVE: After completion of this exercise, the student will be able to use an ammeter correctly.

EXPLANATION: 1.Pass written test with __________% accuracy.
2. Demonstrate to the instructor how to zero set the ammeter, select the proper range, and measure the amperage. Also, the student will be able to read the amperage on the appropriate scale.

MATERIALS NEEDED: D. C. power source (40v. or less)
Necessary wiring
Three light bulbs

TOOLS NEEDED: Ammeter

References	Do
# 1. --	1. Read the assigned reference material
# 2.p.368	2. Study information sheets.
# 3. --	3. Take written test
# 4. p. 469-470	4. Check with instructor
#5. --	5. Sign written test sheet
# 6. p. 243-244	6. Demonstrate proper ammetere useage to instructor (oral test)
# 7. p. 217	7. Instructor sign credit sheet
# 8. --	8. Return tools and materials.

Electrical Competencies- Electri Fundamentals

No. A - 2 How To Use An Ammet

Information Sheet #1

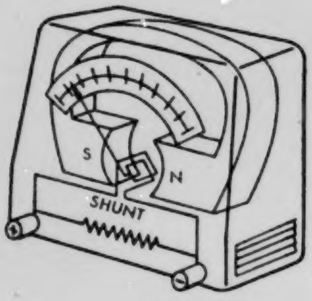
TEST METERS

The use of test meters is an invaluable and essential aid in diagnosing troubles in an electrical circuit. If values of voltage, current and resistance are not measured with suitable test meters, only a guess can be made as to what type of defect exists in the circuit.

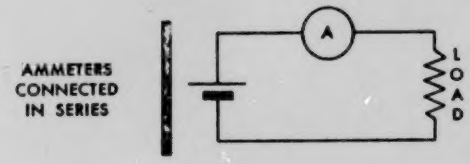
Ammeters

Ammeters also may be of the moving coil type, and differ from voltmeters in that a low resistance shunt is used internally or externally in place of a high resistance. The shunt is connected in parallel with the moving coil, and conducts the major part of the current being measured, leaving only a small portion to flow through the moving coil. The ammeter scale is calibrated in amperes to indicate the total circuit current, since the pointer deflection is directly proportional to the total current flow in the circuit.

Since the ammeter has a very low resistance, it must be connected in series in the circuit, and never across the voltage source. If connected across the voltage cource, such as a battery, the meter may be instantly damaged. Having a very low resistance, connecting the ammeter in series does not introduce any appreciable added resistance to the circuit that would alter the true current flow.



AMMETER



Reading An Ammeter

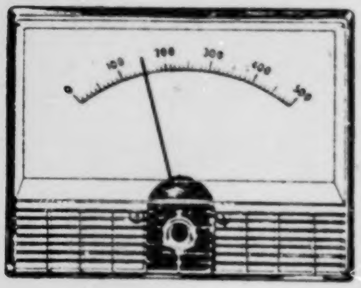
Many ammeters have direct reading scales for all their ranges. Those which don't, have ranges which read in multiples of tens, similar to the ranges of those in voltmeters. (See Voltmeter Information Sheet #1)

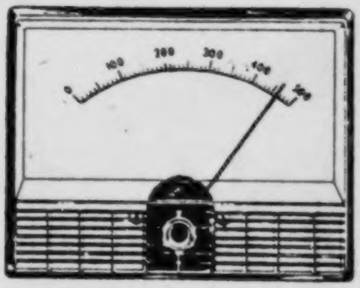
Electrical Competencies- Electrical Fundamentals

No. A - 3 How To Use An Ammeter

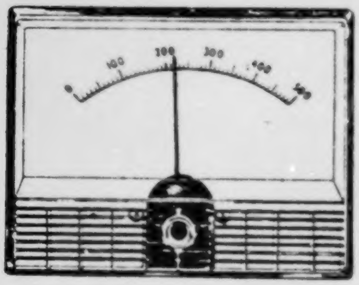
Worksheet # 1

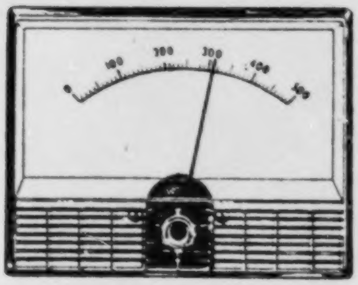
Directions:
In the spaces provided by the corresponding scale selector position, record the indicated ammeter readings.


0
100
200
300
400
500

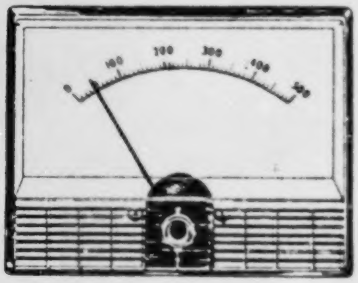

0
100
200
300
400
500

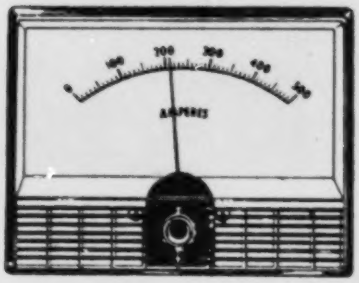
1. 50 amp scale __________a.
2. 500 amp scale __________a.
3. 50 amp scale __________a.
4. 500 amp scale __________a.


0
100
200
300
400
500


0
100
200
300
400
500

5. 50 amp scale __________a.
6. 500 amp scale __________a.
7. 50 amp scale __________a.
8. 500 amp scale __________a.


0
100
200
300
400
500

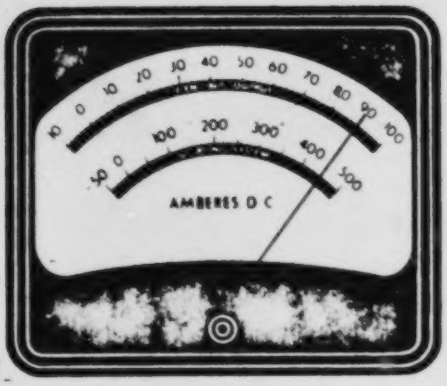

0
100
200
300
400
500
AMPERES

9. 50 amp scale __________a.
10. 500 amp scale __________a.
11. 50 amp scale __________a.
12. 500 amp scale __________a.

No. A - 3 How To Use An Ammeter

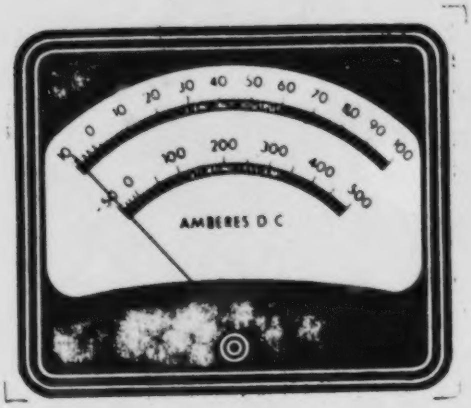
Worksheet # 1
Page 2

Name ________________________ Date __________ Grade __________


10 0 10 20 30 40 50 60 70 80 90 100
-50 0 100 200 300 400 500
AMPERES D C

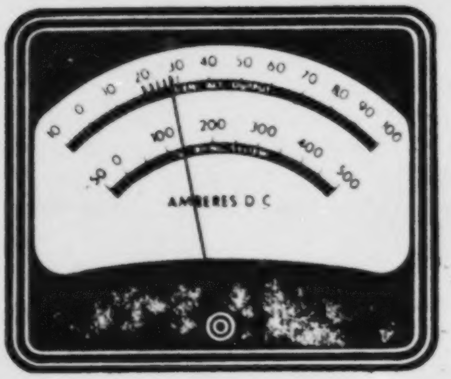
13. 100 amp scale ________a.

14. 500 amp scale ________a.


10 0 10 20 30 40 50 60 70 80 90 100
-50 0 100 200 300 400 500
AMPERES D C

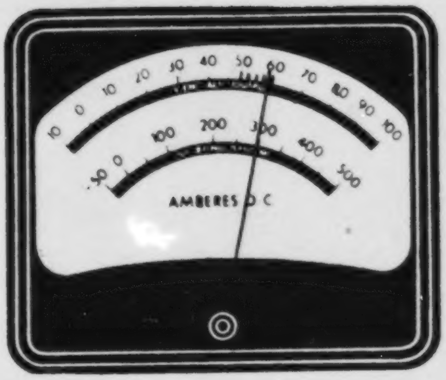
15. 100 amp scale ________a.

16. 500 amp scale ________a.


10 0 10 20 30 40 50 60 70 80 90 100
-50 0 100 200 300 400 500
AMPERES D C

17. 100 amp scale _______a.

18. 500 amp scale _______a.


10 0 10 20 30 40 50 60 70 80 90 100
-50 0 100 200 300 400 500
AMPERES D C

19. 100 amp scale _______a.

20. 500 amp scale _______a.

Electrical Competencies- Electrical Fundamentals

No. A - 3 How To Use An Ammeter

Worksheet #2

Name ____________________ Date ____________________ Grade ____________________

1. The Ammeter and Current Draw

We have hinted at the fact that the amount of electricity flowing in a circuit determines how brightly a lamp will glow, how fast a motor will run, etc. And we have implied that this depends on the available voltage and the resistance. Now it's time to consider the electrical property of current draw.

Current draw or simply current is the measure of electrical volume or flow. It is comparable to gallons per minute in a hydraulic system. The unit of measure is amperes or amps, and the instrument used to measure it is the ammeter.

Connecting the Ammeter

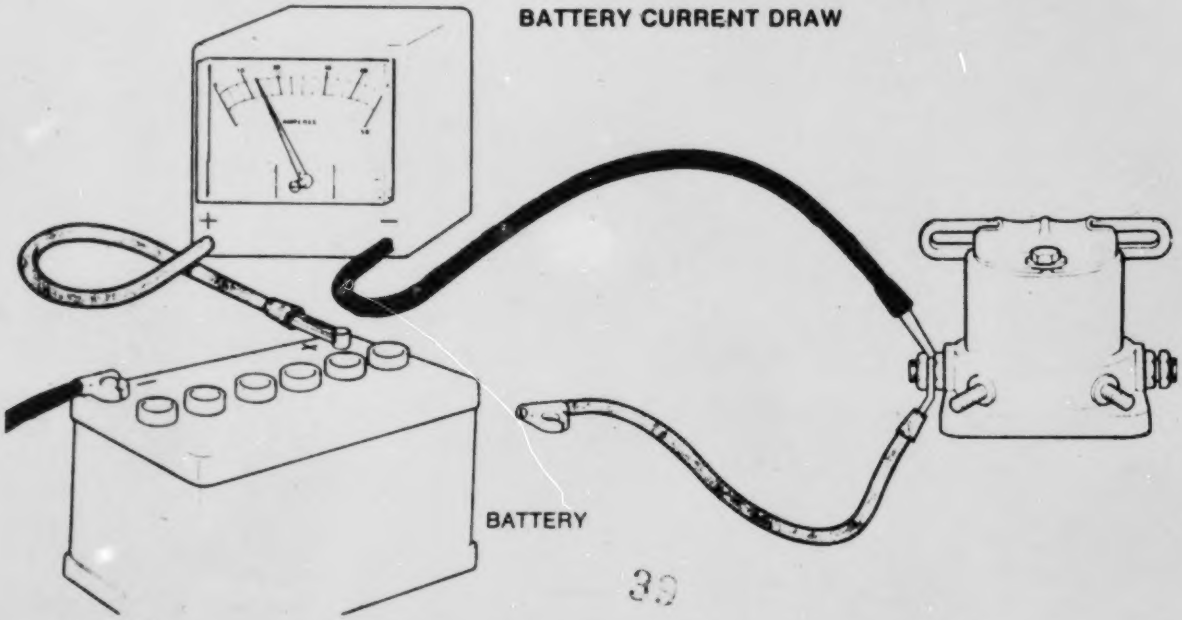
The ammeter is connected into the circuit, in series with the load, switches, resistors, etc. It will measure current draw only when the circuit is closed and electricity is flowing.

In the illustration, we've connected the meter to measure current draw from the battery. The positive lead is to the battery positive terminal. The negative lead is to the starter relay terminal. The positive cable is disconnected so that any current flowing must go through the meter.

If we were to turn on the car's electrcial systems one at a time, the meter would measure how much each draws on the amperes scale.

Now it's not necessary to connect the ammeter at this particular point. You can connect it anywhere in any circuit (even between the load and ground). Just be sure to connect it in series and observe the right polarity of the leads.

BATTERY CURRENT DRAW

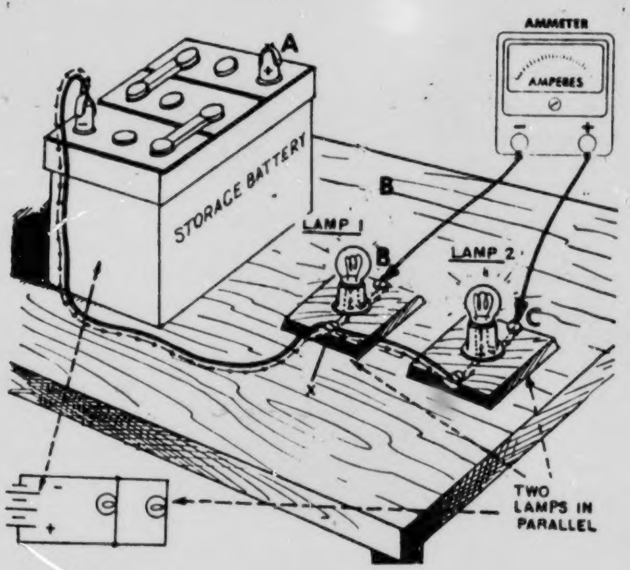


Connect the circuit as shown in the picture on the preceding page and read the current used with lack of the following units on:

a. Headlights (low) __________ __________amps
b. Headlights (high) ____ __________amps
c. Heater (high) ____________________amps
d. Starter ____________________amps

Instructor's Initials ____________

2. This is a parallel circuit. Place a wire from A to B. Connect the ammeter from B to C. Note the ammeter is in series with lamp two; therefore, the read will be the current in lamp two only.



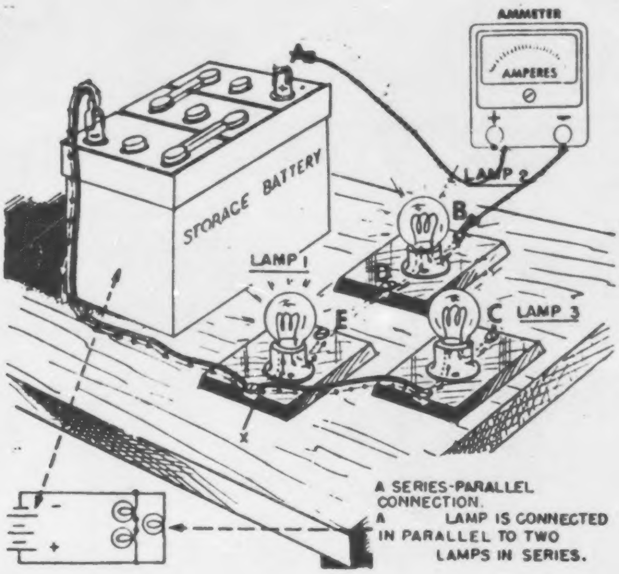
The current flowing in lamp two is ____________amps.

3. Place a wire from B to C. Connect the ammeter between A and B. Note now the ammeter is is series with the whole circuit (both lamps one and two). Their current reading therefore will reflect the current flowing through both lamps (the entire circuit).

The current flowing in the entire curcuit is __________amps.

Instructor's Initials

4. This is a series-parallel circuit. Connect a wire from A to B and D to E. Connect your ammeter from B to C.



A SERIES-PARALLEL CONNECTION.
A LAMP IS CONNECTED IN PARALLEL TO TWO LAMPS IN SERIES.

What is the amperage flowing from B to C? ____________amps

Which lamp(s) are we checking the current through? ___________________________

5. In the circuit for question no. 3, connect a wire from B to C and D to E. Connect your ammeter from A to B.

What is the amperage flowing from A to B? ______________ amps

Which lamp(s) are we checking the current through? __________________________

6. In the circuit for question no. 3, connect a wire from A to C and D to E. Connect your ammeter from A to B.

What is the amperage flowing from A to B? _______________ amps

Which lamp(s) are we checking the current through? ___________________________

Instructor's Initials ___________

7. In the circuit for question no. 3, connect a wire from A to B and B to C. Connect your ammeter from D to E.

What is the amperage flowing from D to E? _____________amps

Which lamp(s) are we checking the current flow through? ____________________

How does this reading compare with the reading in question no. 5?

Explain your answer to the last question giving the reason for you answer.

Instructor's Initials ______

AUTO MECHANICS

Electrical Competencies ‾ Electrical Fundamentals

No. A-4 How To Use An Ohmmeter

OBJECTIVE:

After completion of this exercise, the student will be able to use an ohmmeter correctly.

EXPLANATION:

1. Pass written test with ___% accuracy.
2. Demonstrate to the instructor how to zero the ohmmeter, select the proper range, and measure the resistance value. Also, the student will be able to read the resistance value on the appropriate scale.

MATERIALS NEEDED:

Resistors

TOOLS NEEDED:

Ohmmeter

References	Do
#1. --	#1. Read the assigned reference material.
#2. p. 368	#2. Study information sheets.
#3. --	#3. Do worksheet # 1.
#4. p. 469-470	#4. Check with instructor.
#5. --	#5. Sign written test sheet.
#6. --	#6. Do worksheet # 2.
#7. --	#7. Instructor sign credit sheet.
#8. p. 109-110	#8. Return tools and materials.
	#9. Take meters test.

Electrical Competencies- Electrical Fundamentals

No. A - 4 How To Use An Ohmmeter

Information Sheet # 1

TEST METERS

The use of test meters is an invaluable and essential aid in diagnosing troubles in an electrical circuit. If values of voltage, current and resistance are not measured with suitable test meters, only a guess can be made as to what type of defect exists in the circuit.

Ohmmeters

An ohmmeter also may be of the moving coil type, and contains a resistor and dry cell battery connected internally to the moving coil. When the ohmmeter is connected to a resistor, the current flow through the moving coil is directly related to the value of the resistor, and the scale is calibrated accordingly to indicate the resistor value in ohms. Ohmmeters should never be connected to an external source of voltage, as the meter movement may be damaged.

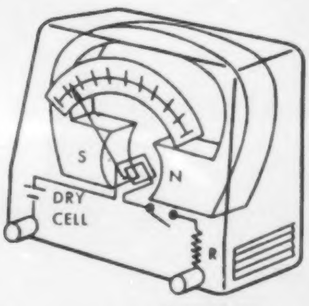
The ohmmeter measures the amount of electrical resistance in a circuit. It is primarily used in detail testing electrical components like coils, relays and spark plug wires.

Examples of typical resistance measurements are; resistance of primary and seconda[illegible] windings of ignition coils, of ballast resistors and spark plug wires.

The ohmmeter uses two leads. All measurements are made with the circuit open and with NO power applied.

The OHM selector knob is used to select one of the four ranges of resistance to be measured. The ohmmeter scale is read from right to left (opposite to the normal direction).
In the X1 position, read the scale directly.
In the X10 position, read the scale and add one zero to the reading.
-Example-- 4 becomes 40.
In the X100 position, read the scale and add two zeros to the reading.
-Example-- 4 becomes 400.
In the X100 position, read the scale and add three zeros to the reading.
-Example-- 4 becomes 4000.

Always calibrate the ohmmeter after selecting the range by connecting the test leads together and turning the OHM CALIBRATOR knob until the meter reads on the Set Line.



OHMMETER

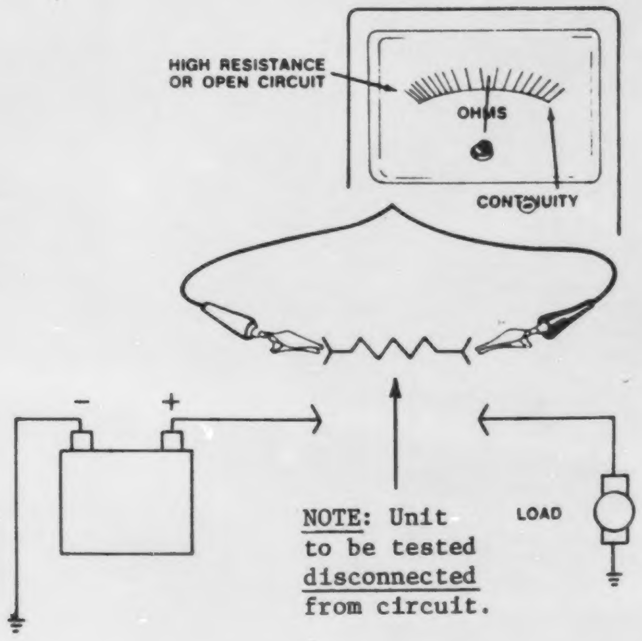
OHMMETER TESTS

The ohmmeter is used to (1) measure resistance, or (2) check for continuity. Where an actual resistance specification exists, you'll naturally take the reading on the ohmmeter scale.

But if you're only trying to determine if the circuit is open or closed:

-A low or zero reading indicates continuity
-A full-scale (∞) reading indicates no continuity.

Since the ohmmeter is self-powered, the component being tested must be isolated from the circuit power.



NOTE: Unit to be tested disconnected from circuit.

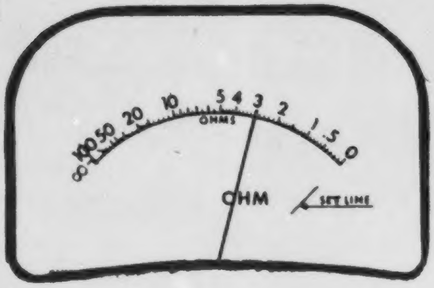
Electrical Competencies- Electrical Fundamentals

No. A - 4 How To Use An Ohmmeter

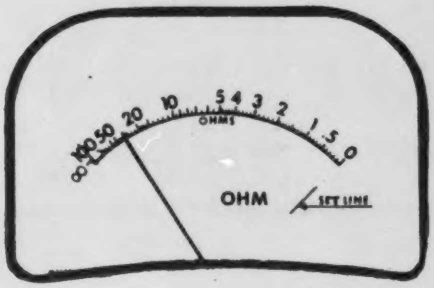
Worksheet # 1

Name ______________________ **Date** ____________ **Grade** ____________

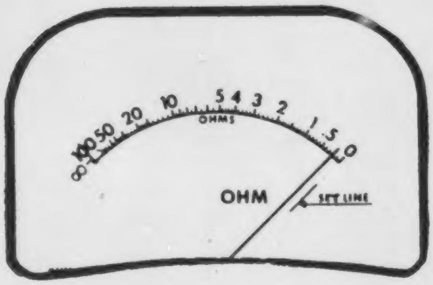
Directions:
In the spaces provided by the corresponding scale selector position record the indicated ohmmeter readings.


∞ 100 50 20 10 5 4 3 2 1 .5 0
OHMS
OHM
SET LINE

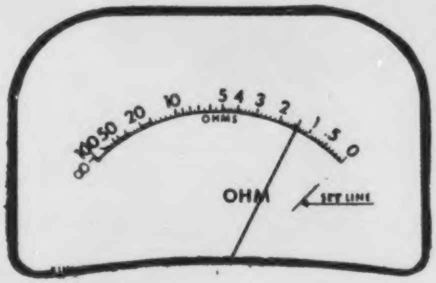
1. Ohms x 1 ____________ ohms
2. Ohms x 10 ____________ ohms
3. Ohms x 100 ____________ ohms
4. Ohms x 1,000 ____________ ohms


∞ 100 50 20 10 5 4 3 2 1 .5 0
OHMS
OHM
SET LINE

5. Ohms x 1 ____________ ohms
6. Ohms x 10 ____________ ohms
7. Ohms x 100 ____________ ohms
8. Ohms x 1,000 ____________ ohms


∞ 100 50 20 10 5 4 3 2 1 .5 0
OHMS
OHM
SET LINE

9. Ohms x 1 ____________ ohms
10. Ohms x 10 ____________ ohms
11. Ohms x 100 ____________ ohms
12. Ohms x 1,000 ____________ ohms


∞ 100 50 20 10 5 4 3 2 1 .5 0
OHMS
OHM
SET LINE

13. Ohms x 1 ____________ ohms
14. Ohms x 10 ____________ ohms
15. Ohms x 100 ____________ ohms
16. Ohms x 1,000 ____________ ohms

Electrical Competencies- Electrical Fundamentals

No. A - 4 How To Use An Ohmmeter

Worksheet # 2

Name ______________________________ Date ____________ Grade __________

1. Obtain four high tension leads from your instructor. In the spaces provided, record the resistances in the appropriate blank.

   A. __________ohms
   B. __________ohms
   C. __________ohms
   D. __________ohms

2. Obtain four resistors from your instructor. In the spaces provided, record the resistances in the appropriate blanks.

   A. __________ohms
   B. __________ohms
   C. __________ohms
   D. __________ohms

3. Obtain three ignition coils from you instructor. In the corresponding spaces provided, record the primary and secondary resistances.

   A. Primary __________ohms
   Secondary __________ohms
   B. Primary __________ohms
   Secondary __________ohms
   C. Primary __________ohms
   Secondary __________ohms

4. Obtain six test light bulbs from your instructor. In the corresponding spaces provided, record the resistances of each.

   A. Headlight High Beam __________ohms
   Low Beam __________ohms
   B. Headlight High Beam __________ohms
   Low Beam __________ohms
   C. Taillight Brake Filament ____________ohms
   Tail Filament ____________ohms
   D. Taillight Brake Filament ____________ohms
   Tail Filament ____________ohms
   E. Double contact bulb ____________ohms
   F. Single contact bulb ____________ohms

5. What is indicated if you get a low or zero reading on the ohmmeter?

   ____

6. What is indicated if you get a full scale, infinite (∞), reading on the ohmmeter? ____

   ____

Electrical Competencies- Electrical Fundamentals

No. A - 4 How To Use An Ohmmeter

Test # 1

Name ______________________________ Date __________________ Grade ________________

1. Voltage is:
   a. Electrical flow
   b. Electrical pressure
   c. Electrical resistance
   d. Electrical capacity
   e. None of the above

2. Current is:
   a. Electrical flow
   b. Electrical pressure
   c. Electrical resistance
   d. Electrical capacity
   e. None of the above

3. An ohm is a measure of:
   a. Electrical flow
   b. Electrical pressure
   c. Electrical resistance
   d. Electrical capacity
   e. None of the above

4. When using an ohmmeter, the item being checked:
   a. Should be electrically removed from the circuit
   b. Need not be removed from the circuit
   c. May be checked while the circuit is live
   d. No special precautions are necessary
   e. Must always be grounded to the car frame

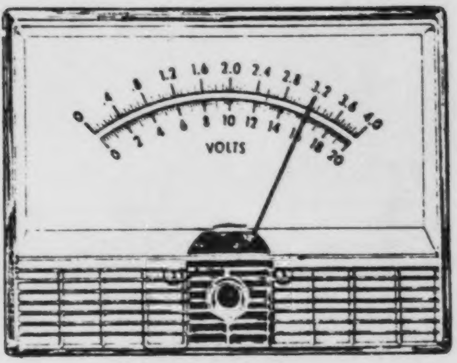
5. An ammeter must always be connected into a circuit by means of a :
   a. perpendicular circuit
   b. parallel circuit
   c. series-parallel circuit
   d. series circuit
   e. Any of the above

6. While making tests with a voltmeter, it is connected into the circuit by means of a:
   a. perpendicular circuit
   b. parallel circuit
   c. series-parallel circuit
   d. series circuit
   e. Any of the above

7. The correct test instrument to be used to measure electrical pressure is:
   a. voltmeter
   b. ohmmeter
   c. ammeter
   d. hydrometer
   e. all of the above

8. The correct test instrument used to measure electrical resistance is:
   a. voltmeter
   b. ammeter
   c. ohmmeter
   d. hydrometer
   e. tachometer

9. The correct test instrument used to measure the volume of electron flow is:
   a. voltmeter
   b. ammeter
   c. ohmmeter
   d. hydrometer
   e. tachometer

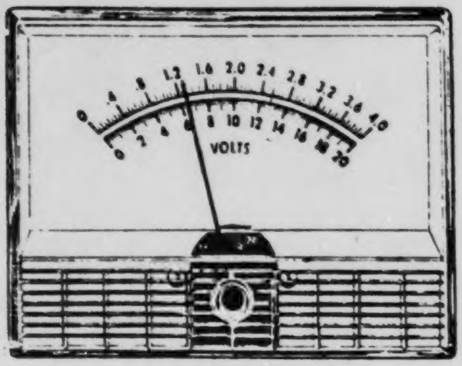


Meter 1

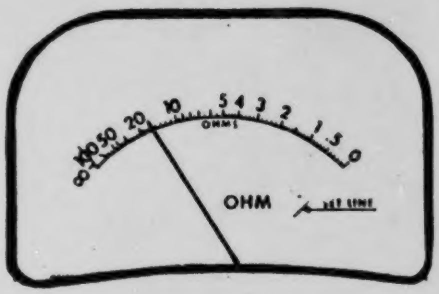
10. With the selector switch on the 4 volt position, the reading on meter 1 is:
    a. 16 volts
    b. 3.2 volts
    c. 32 volts
    d. 160 volts
    e. .32 volts

11. With the selector switch on the 20 volt position, the reading on meter 1 is:
    a. 16 volts
    b. 3.2 volts
    c. 32 volts
    d. 160 volts
    e. .32 volts

12. With the selector switch on the 40 volt position, the reading on meter 1 is:
    a. 16 volgs
    b. 3.2 volts
    c. 32 volts
    d. 160 volts
    e. .32 volts.



Meter 2



Meter 3

13. With the selector switch on the 4 volt position, the reading on meter 2 is:
    a. 7 volts
    b. 65 volts
    c. 6.5 volts
    d. 1.3 volts
    e. 13 volts

14. With the selector switch on the 20 volt position, the reading on meter 2 is:
    a. 7 volts
    b. 65 volts
    c. 6.5 volts
    d. 1.3 volts
    e. 13 volts

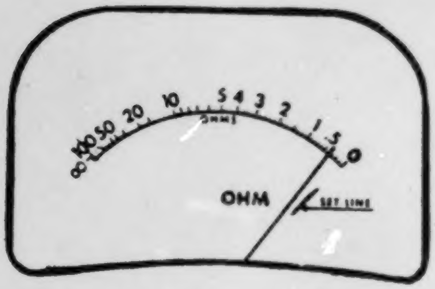
15. With the selector switch on the 40 volt position, the reading on meter 2 is:
    a. 7 volts
    b. 65 volts
    c. 6.5 volts
    d. 1.3 volts
    e. 13 volts

16. With the selector switch on the Ohms x 1 position, the reading on meter 3 is:
    a. 15,000 ohms
    b. 1,500 ohms
    c. 150 ohms
    d. 15 ohms
    e. 1.5 ohms

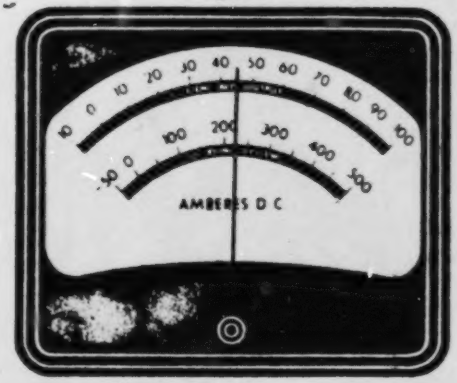
17. With the selector switch on the Ohms x 1,000 position, the reading on meter 3 is:
    a. 15,000 ohms
    b. 1,500 ohms
    c. 150 ohms
    d. 15 ohms
    e. 1.5 ohms

18. With the selector switch on the Ohms x 10 position, the reading on meter 3 is:
    a. 15,000 ohms
    b. 1,500 ohms
    c. 150 ohms
    d. 15 ohms
    e. 1.5 ohms

No. A - 4 How To Use An Ohmmeter


∞
100
50
20
10
5
4
3
2
1
.5
0
OHMS
OHM
SET LINE

Meter 4


10
0
10
20
30
40
50
60
70
80
90
100
50
0
100
200
300
400
500
AMPERES D C

Meter 5

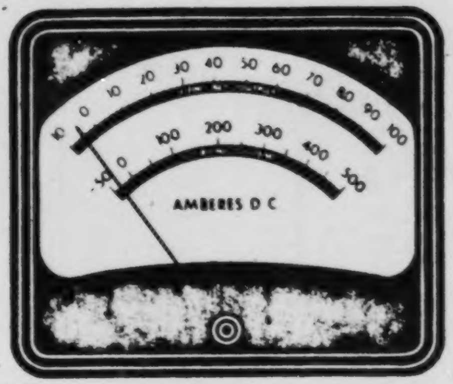
19. With the selector switch on the ohms x 100 position, the reading on meter 4 is:
    a. .4 ohms
    b. 4 ohms
    c. 40 ohms
    d. 400 ohms
    e. 4,000 ohms

20. With the selector switch on the ohms x 1 position, the reading on meter 4 is:
    a. .4 ohms
    b. 4 ohms
    c. 40 ohms
    d. 400 ohms
    e. 4,000 ohms

21. With the selector switch on the ohms x 1,000 position, the reading on meter 4 is:
    a. .4 ohms
    b. 4 ohms
    c. 40 ohms
    d. 400 ohms
    e. 4,000 ohms

22. With the selector switch on the 100 amp scale, the reading on meter 5 is:
    a. 4.5 amps
    b. 45 amps
    c. 450 amps
    d. 22.5 amps
    e. 225 amps

23. With the selector switch on the 500 amp scale, the reading on meter 5 is:
    a. 4.5 amps
    b. 45 amps
    c. 450 amps
    d. 22.5 amps
    e. 225 amps


10
0
10
20
30
40
50
60
70
80
90
100
50
0
100
200
300
400
500
AMBERES D C

Meter 6

24. With the selector switch on the 500 amp scale, the reading on meter 6 is:
    a. 5 amps
    b. -5 amps
    c. 25 amps
    d. -25 amps
    e. -250 amps

25. With the selector switch on the 100 amp scale, the reading on meter 6 is:
    a. 5 amps
    b. -5 amps
    c. 25 amps
    d. -25 amps
    e. -250 amps

AUTO MECHANICS

Electrical Competencies - Electrical Fundamentals

No. A-5 How To Identify Components, Symbols, and Circuit Protection Devices

OBJECTIVE: After completion of this exercise, the student will be able to identify __________ of the common electrical circuit components and symbols

EXPLANATION: 1. Pass written test with ________ % accuracy.

MATERIALS NEEDED:
None

TOOLS NEEDED:

None

References	Do
#1. p. 6-1 to 6-13	1. Read the assigned references.
#2. p. 398-401	2. Read the information sheets.
#3. p.445	3. Do worksheet # 1
#4. p.431-433	4. Check with instructor
#5. p. 522-527	5. Take unit test
#6. p. 322-333	
#7. p. 282-290	
#8. p. 37-38, 47-52	

No. A - 5 Component Identification

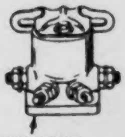
Information Sheet #1

Components

Placed throughout the vehicle on various electrical components that the student should be able to recognize. Here are a number of the most common ones you should be able to recognize.

1. Starter Relays

Most starter relays are mounted on the starter. However, on some makes of cars, the solenoid is mounted seperately on the inner fender or firewall. In the vehicles which use this separate solenoid the unit looks like this:

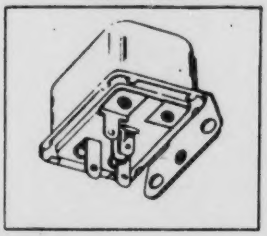


STARTER RELAY

2. Horn Relay

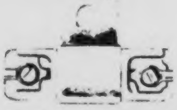
Because horns draw a very high current, many vehicles use a horn relay to eliminate the need for high current capability in the horn button switch. Many newer cars have high current capacity switches in the horn button or use a low current horn, or have a combination of both of these features to eliminate the use of a horn relay. In either case, it sould be noted that the horn is operated by grounding the relay of the horn itself. Because of this circuit, there is always power at the horn or relay.

POWER RELAY



3. Ignition (Ballast) Resistor

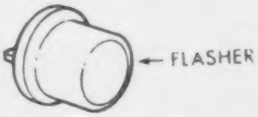
To reduce 12v. battery voltage to a level which will not so rapidly burn points, a resistor is placed between the coil and the ignition switch. This resistor can take the form of a porcelain block with a coil of nicrome wire inside or a resistor within the wire from the ignition switch. The resistor within a wire looks like an extra heavy piece of wire. With either type of resistor it should be noted the resistor is bypassed when the engine is cranked, applying 12v. directly to the coil to give increased starting power. The porcelain type resistor looks like this:



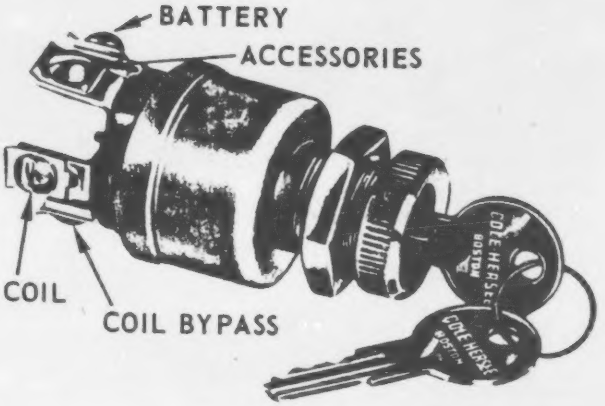
IGNITION RESISTOR

4. Turn Signal Flasher

This is a small tin can like unit mounted on the fuse block under the dash. On some older model cars the unit may mount in a holder under the dash and plug into the wiring harness.

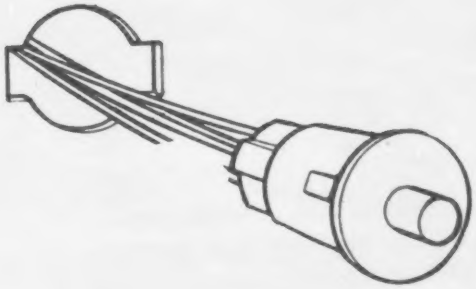


5. Ignition Switch



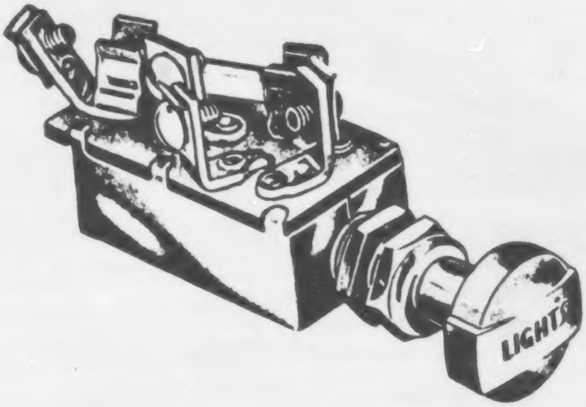
Typical ignition switch. Coil bypass terminal furnishes current directly to coil (without passing through ballast resistor) during engine cranking.

6. Door Switch



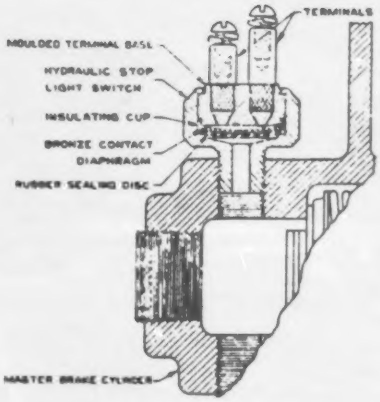
7. Head Lamp Switch

The head lamp switch closes the head lamp circuit; operates the parking lights, taillights, instrument and other dash lights, etc. It may be of the push-pull or the turn type. Some cars use a toggle (up-and-down motion) switch.

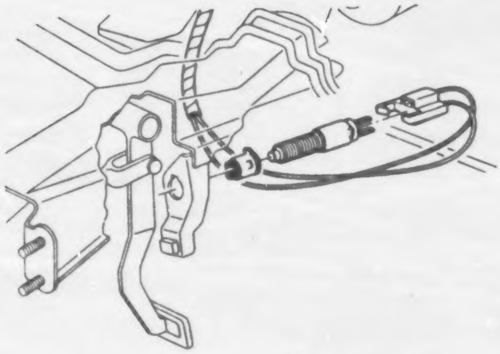


Head lamp switch. Head lamp switches vary a great deal from car to car.

8. Brake Light Switches

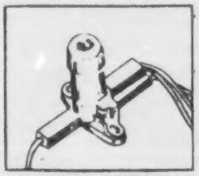

TERMINALS
MOULDED TERMINAL BASE
HYDRAULIC STOP LIGHT SWITCH
INSULATING CUP
BRONZE CONTACT DIAPHRAGM
RUBBER SEALING DISC
MASTER BRAKE CYLINDER

Stoplight switch installed on hydraulic brake master cylinder.



Details of stoplight switch mounted on brake pedal.

9. Head Light Selector Switch (Dimmer Switch)
A dimmer switch is located in the head lamp circuit. It is a simple switch that will direct current to one of the two terminals but never to both. One terminal leads to the high beam filament; the other, to the low beam. The high beam terminal also feeds current to the high beam indicator lamp on the dash.



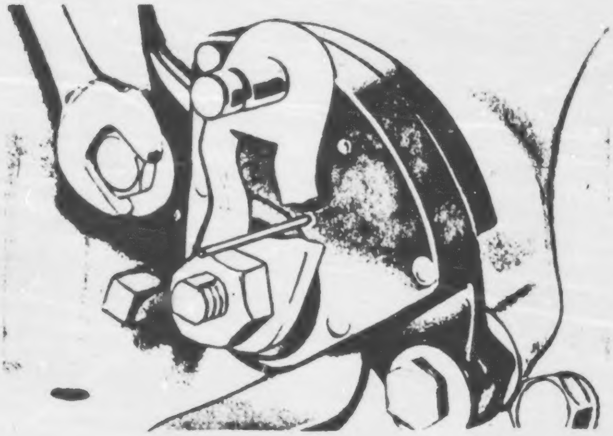
FOOT SWITCH

10. Neutral-Start Switch
A neutral-start switch is installed on vehicles equipped with a floor-shift automatic transmission. This switch opens the start circuit on some vehicles in all selector lever poritions except PARK or NEUTRAL. On some vehicles, it permits starting in the PARK position only.

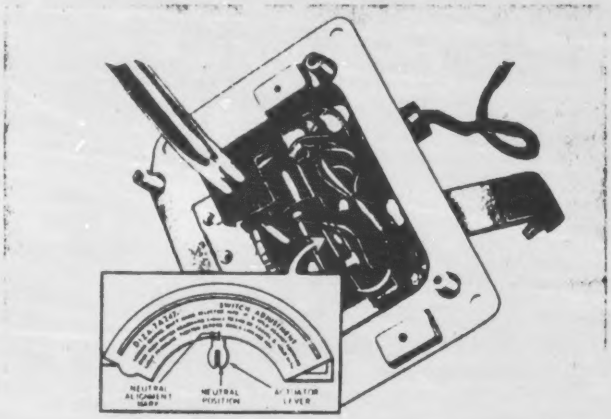
The switch is located in the start control circuit between the ignition-start switch and the starter relay or solenoid.

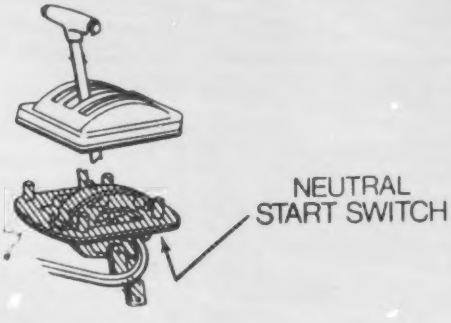
Two types of switches are used on passenger cars.

NEUTRAL-START SWITCH
MOUNTED ON TRANSMISSION



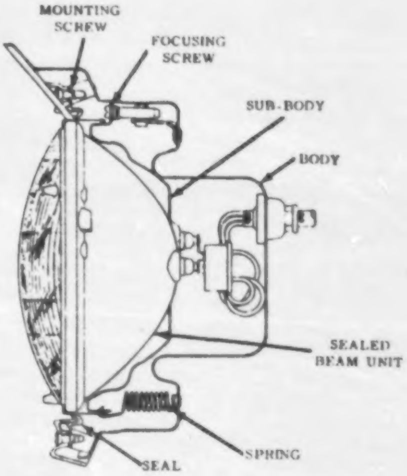
NEUTRAL-START SWITCH
LOCATED IN CONSOLE





11. Headlights

The modern headlight is of sealed beam construction. The filament, reflector and lens are fused into one airtight unit. Prongs that fit into a socket connector make removal easy.



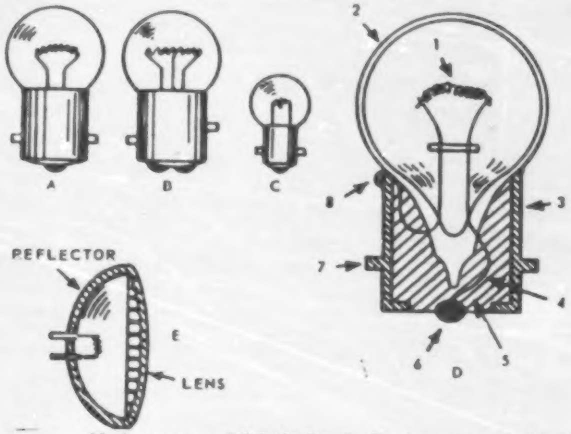
Head lamp assembly.

12. Bulbs

Light bulbs used throughout the car are either of the single or double contact type.

Some bulbs have two filaments. This allows the bulb to be used for two separate lighting jobs. The taillight bulb is an example of this type. It is used for both a taillight and stoplight.

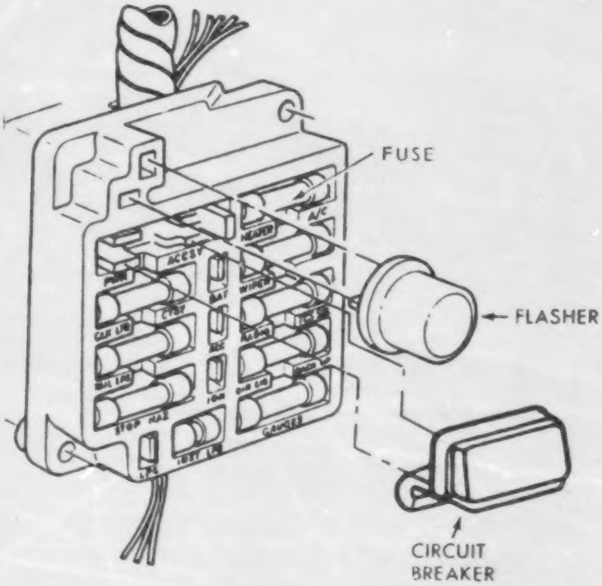
Bulbs must be of the proper candlepower (measurement of light intensity) and voltage.



Various types of light bulbs. A—Single contact. B—Double contact. C—Midget type. D—Cross section of a typical bulb. 1—Filament. 2—Glass. 3—Brass base. 4—Filament lead. 5—Glass-like cement. 6—Contact. 7—Holding pins. 8—Filament ground lead soldered to brass base. Current travels up from contact through filament, then to ground through brass base. E—Cross section of sealed beam head lamp. Unit is one piece. Reflector is silvered to provide good reflective properties. Lens controls and directs light.

13. Fuse Block

Most newer cars use a circuit fuse block. It may be mounted on the fire wall near the stearing column or in the glove compartment. Many fuse blocks also have sockets to mount flashes and circuit breakers.



Typical fuse block or panel.

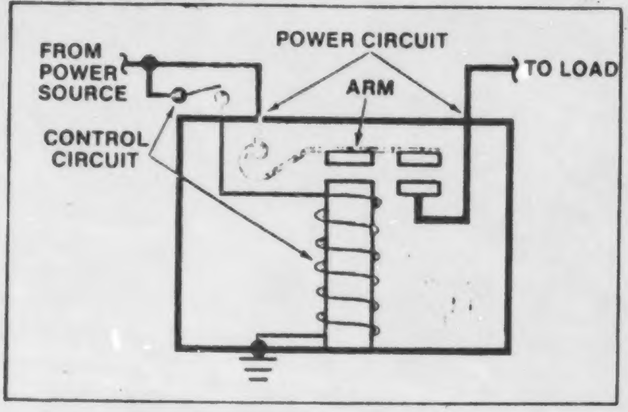
14. Electromagnetic Components

When an electrical current passes through a conductor a magnetic field is set up around the conductor. If the conductor is coiled, the magnetic field becomes concentrated and stronger. This electromagnetism is put to practical uses in such components as relays, buzzers, and solenoids.

Relays

A relay is essentially a remote-controlled switch. A small amount of current can control the relay, while the relay itself can switch a large current on or off. By this means large heavy conductors do not have tc be used to carry high current all the way back to the control point.

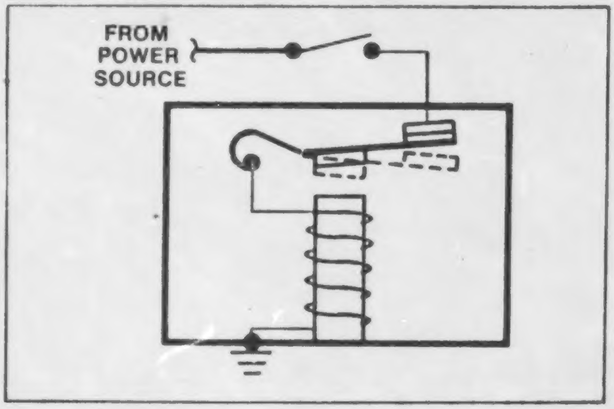
Illustration below shows a typical relay construction. When the switch is open no current flows to the coil, so the relay is de-energized. When the switch is closed the coil is energized, the metal core within the coil is magnetized, the relay arm is drawen down, and the circuit is made from the power source to the load. When the switch is opened, the coil is de-energized, the metal core at the coil is de-magnetized, and the spring-loaded arm moves up, breaking the circuit.



TYPICAL RELAY CONSTRUCTION

Buzzers

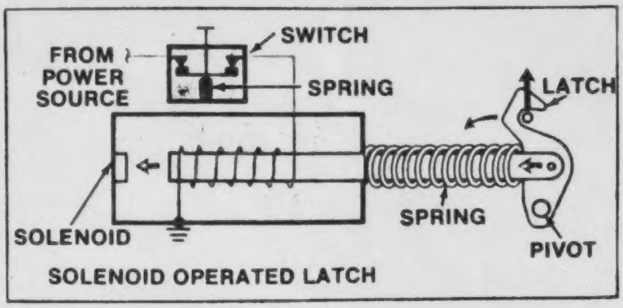
As shown, a buzzer is similar to a relay but its internal connections are different. When the switch is closed, here, the current flows through the normally closed contacts and energizes the coil. When the coil core becomes magnetized, it draws the arm down, breaking the circuit. As soon as the circuit is broken, the spring-loaded arm re-makes the circuit, again energizing the coil. This cycle is repeated rapidly to cause the buzzing sound.



TYPICAL BUZZER CONSTRUCTION

Solenoids

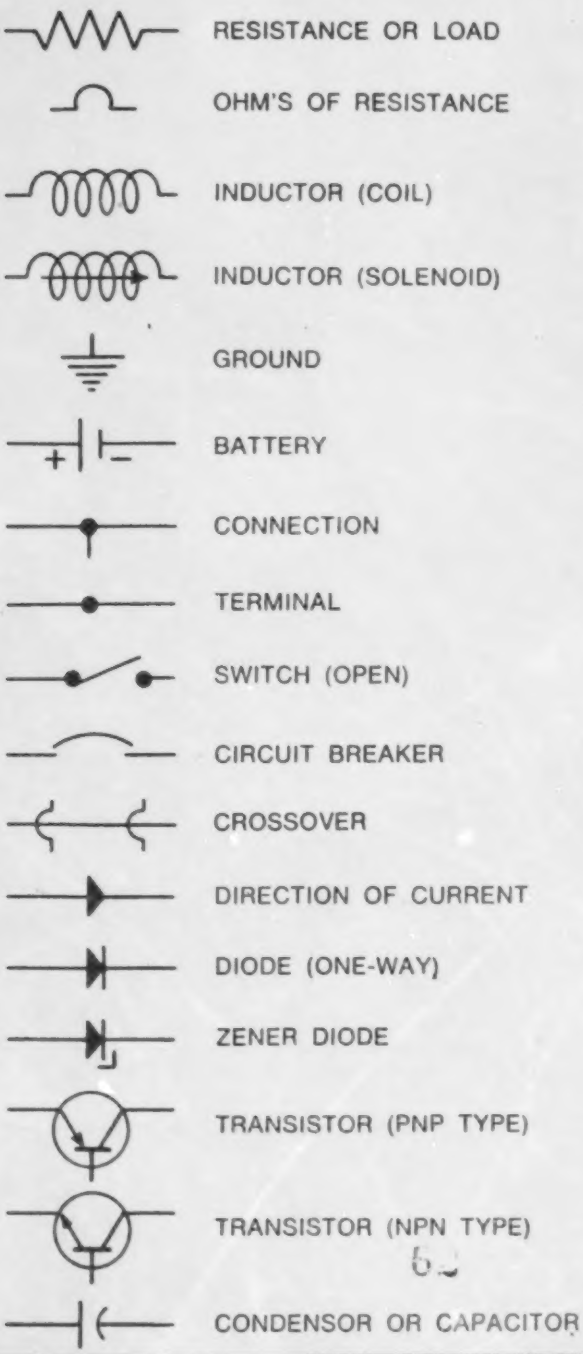
A solenoid is constructed like a relay, except that its core is allowed to move, providing mechanical motion. As shown when the switch is closed, the coil is energized, the movable core is drawn into the coil, and the latch is moved. When the switch is opened, the coil is de-energized, and spring pressure returns the core and latch to their original position. The circuit and symbol for the solenoid in the luggage compartment latch mechanism is shown.

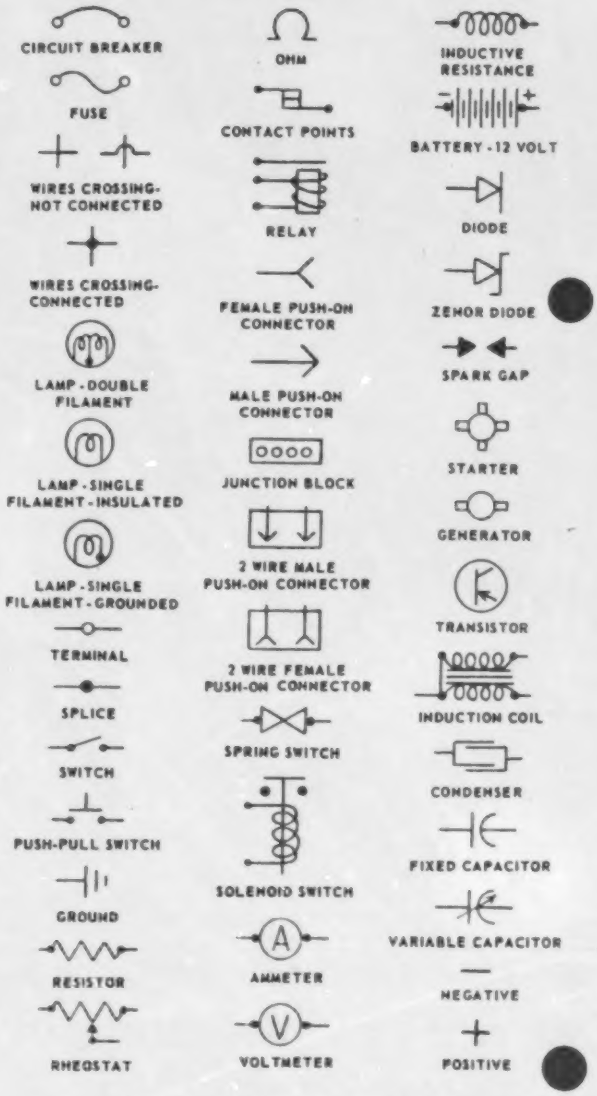

SWITCH
FROM POWER SOURCE
SPRING
LATCH
SPRING
SOLENOID
PIVOT
SOLENOID OPERATED LATCH

TYPICAL SOLENOID CONSTRUCTION

Electrical Wiring Symbols

There is a wide variation in the use of automotive electrical symbols. Some companies use their own drawings for some units and standard symbols for others. The units basic internal circuit is sometimes shown and in other diagrams, symbols are used for all units. The following illustrates a number of typical symbols used in automotive electrical diagrams.


RESISTANCE OR LOAD
OHM'S OF RESISTANCE
INDUCTOR (COIL)
INDUCTOR (SOLENOID)
GROUND
+
−
BATTERY
CONNECTION
TERMINAL
SWITCH (OPEN)
CIRCUIT BREAKER
CROSSOVER
DIRECTION OF CURRENT
DIODE (ONE-WAY)
ZENER DIODE
TRANSISTOR (PNP TYPE)
TRANSISTOR (NPN TYPE)
CONDENSOR OR CAPACITOR

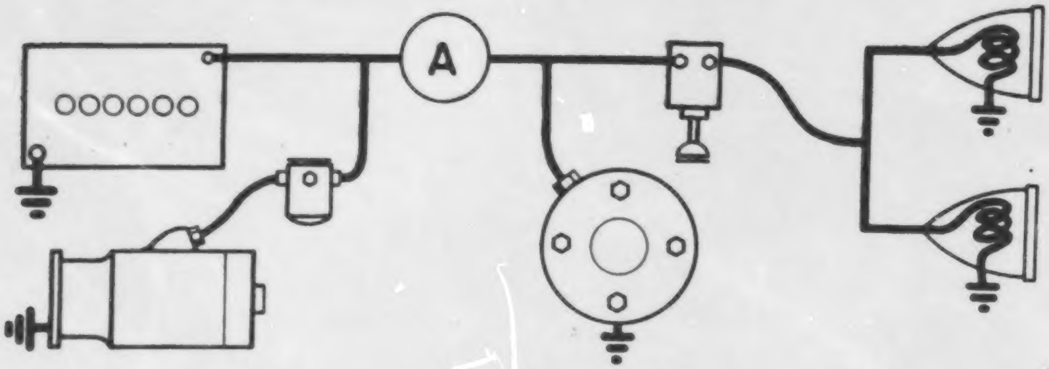

CIRCUIT BREAKER
FUSE
WIRES CROSSING-NOT CONNECTED
WIRES CROSSING-CONNECTED
LAMP-DOUBLE FILAMENT
LAMP-SINGLE FILAMENT-INSULATED
LAMP-SINGLE FILAMENT-GROUNDED
TERMINAL
SPLICE
SWITCH
PUSH-PULL SWITCH
GROUND
RESISTOR
RHEOSTAT
OHM
CONTACT POINTS
RELAY
FEMALE PUSH-ON CONNECTOR
MALE PUSH-ON CONNECTOR
JUNCTION BLOCK
2 WIRE MALE PUSH-ON CONNECTOR
2 WIRE FEMALE PUSH-ON CONNECTOR
SPRING SWITCH
SOLENOID SWITCH
A
AMMETER
V
VOLTMETER
INDUCTIVE RESISTANCE
BATTERY-12 VOLT
DIODE
ZENOR DIODE
SPARK GAP
STARTER
GENERATOR
TRANSISTOR
INDUCTION COIL
CONDENSER
FIXED CAPACITOR
VARIABLE CAPACITOR
NEGATIVE
POSITIVE

Electrical symbols commonly used in automotive wiring diagrams.

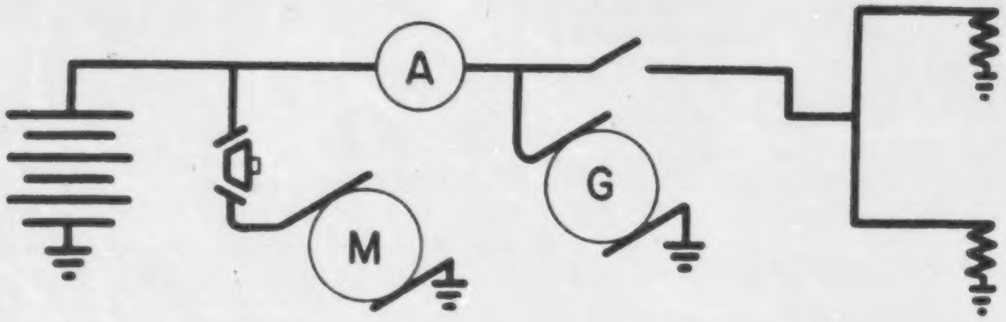
Wiring Diagram And Schematic Diagram

Note the difference in the two diagrams shown. The wiring diagram uses pictures of the component parts. The schematic diagram uses symbols for the parts.

WIRING DIAGRAM



SCHEMATIC DIAGRAM



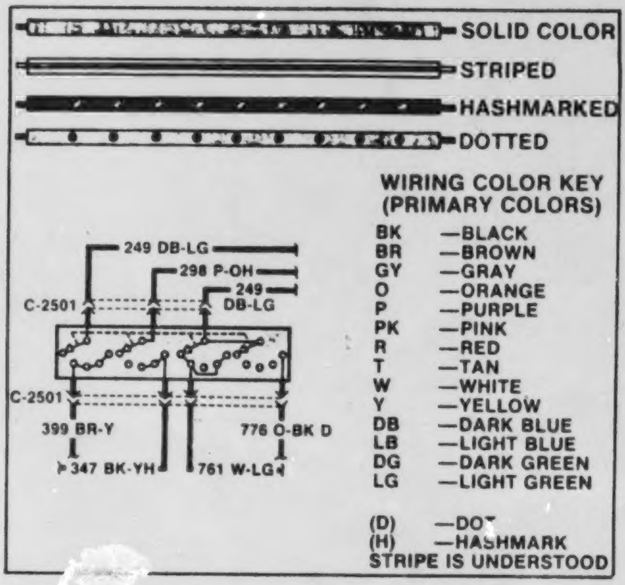
Identifying Conductor Colors

The diagram wiring usually has a color and circuit code system that makes it easier to follow and identify an individual circuit not only in the wiring diagram but also on the vehicle. With a little effort, any of the coding systems can easily be self-taught in a few minutes. In some cases, the wires are shown in their actual color.

Color Markings and Key

Wires are color coded in one of four ways (See Illustration Below):

1. Solid color
2. Base color with stripe
3. Base color with hashmark
4. Base color with dot


SOLID COLOR
STRIPED
HASHMARKED
DOTTED
WIRING COLOR KEY
(PRIMARY COLORS)
BK —BLACK
BR —BROWN
GY —GRAY
O —ORANGE
P —PURPLE
PK —PINK
R —RED
T —TAN
W —WHITE
Y —YELLOW
DB —DARK BLUE
LB —LIGHT BLUE
DG —DARK GREEN
LG —LIGHT GREEN
(D) —DOT
(H) —HASHMARK
STRIPE IS UNDERSTOOD
249 DB-LG
298 P-OH
249 DB-LG
C-2501
C-2501
399 BR-Y
347 BK-YH
761 W-LG
776 O-BK D

CONDUCTOR IDENTIFICATION AND COLOR CODE KEY

On the wiring diagrams the wires are coded by the circuit number, then by the color code(249 DB-LG). Shown above are the abbreviations for the various colors used:

249 DB-LG indicates Circuit No. 249 -- Dark Blue wire with a Light Green stripe.
347 BK-Y H indicates Circuit No. 347-- Black wire with a Yellow hashmark.
776 O-BK D indicates Circuit No. 776 -- Orange wire with a Black dot.

Circuit numbers are cross refereneced in the introductory part of the wiring diagram book by two methods:

1. Circuit number
2. Color

Shown below are typical standard wire code charts. The Standard Wire Color Code Chart (by Circuit) lists the circuits (from Circuit NO. 1 up) and refers the circuit number to a circuit description and color.

The Standard Wire Color Code Chart (by Color) lists all of the circuits by color (alphabetically) and references the wire colors to circuit number and description.

STANDARD WIRE COLOR CODE CHART (BY CIRCUIT)

CIRCUIT	DESCRIPTION	COLOR
1	HORN SWITCH CONTROL	DK BLUE BASE
2	R.H. FRONT TURN SIGNAL LAMP	WHITE-LT BLUE STRIPE
3	L.H. FRONT TURN SIGNAL LAMP	LT GREEN-WHITE STRIPE
4	ALTERNATOR REG "S" TERM TO ALTERNATOR "S" TERM	WHITE-BLACK STRIPE
5	R.H. REAR TURN SIGNAL LAMP	ORANGE-LT BLUE STRIPE

STANDARD WIRE COLOR CODE CHART (BY COLOR)

COLOR	CIRCUIT	DESCRIPTION
(COLOR OPT)	48	BLIND CIRCUIT TERMINATES IN HARNESS CANNOT BE CHECKED FOR CONTINUITY
BLACK	57	GROUND CIRCUIT
BLACK	488	CIRCUIT BREAKER TO HEADLAMP SWITCH BATTERY TERMINAL
BLACK	207	MARKER LAMP SWITCH TO MARKER LAMP
BLACK	505	HEADLAMP DIMMER SWITCH TO HEADLAMP AMPLIFIER

No. A - 5 How To Identify Components, Symbols,
and Circuit Protection Devices

Information Sheet #3

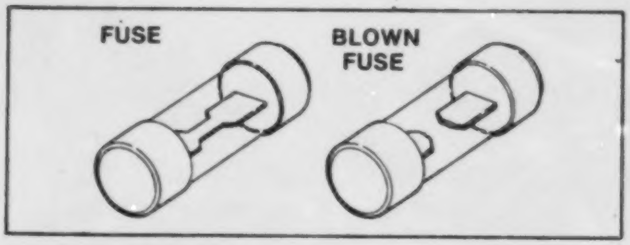
Circuit Protection Devices

When overloads in a circuit cause too much current to flow, the wiring in the circuit will heat up, the insulation will melt, and a fire may result, unless the circuit has some sort of protection device. Devices such as fuses, fuse links, and circuit breakers are designed into circuits to provide protection from overloads.

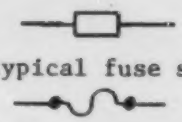
Fuses

Fuses are the type of protection devices most generally used in automobile electrical systems. The fuse shown below is the type of fuse most commonly used. It is merely a strip of low-melting-point metal enclosed in a glass tube. If an excessive amount of current flows through the circuit, the fuse melts at the narrow portion of the metal strip. This action opens the circuit and prevents damage to components.

Fuses are designed to carry a preset maximum amount of current and to blow when that maximum is exceeded. The maximum amperage rating of each fuse is marked on the fuse. Fuses of this type come in different lengths- usually three different lengths for automotive uses. Generally, the longer the fuse, the higher amperage rating. Because this type is contained in a glass tube, it is easy to determine that the fuse has blown. When a fuse blows it should be replaced with a fuse of the same amperage rating- never with a fuse of higher rating.



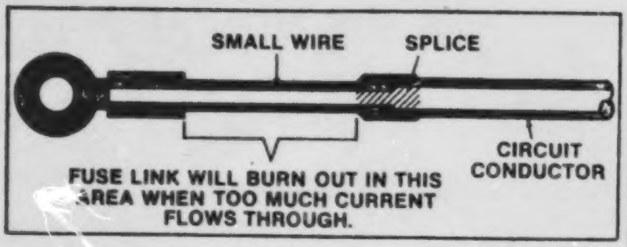
NORMAL AND BLOWN AUTOMOTIVE-TYPE FUSES



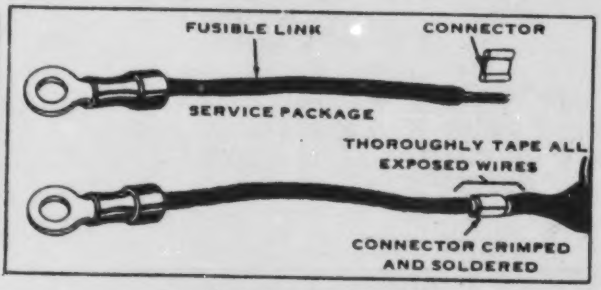
typical fuse symbols

Fuse Link

In circuits where maximum current control is not so critical, a fuse link shown below may be used. A fuse link is a short length of smaller-gauge wire installed in a conductor. Usually the fuse link is installed close to the power source. Because the fuse link is a lighter gauge wire than the conductor wire, if an overload occurs, the fuse link will melt and open the circuit before damage to the rest of the circuit can take place. Fuse link wire is covered with heat-resistant insulation which bubbles up when the fuse link melts; therefore, the blisters on the insulation indicate when the fuse link has melted. To replace a fuse link, cut the conductor at the fuse link splice and splice in a new fuse link of the same rating and crimp it on with a butt connector.


SMALL WIRE
SPLICE
CIRCUIT CONDUCTOR
FUSE LINK WILL BURN OUT IN THIS AREA WHEN TOO MUCH CURRENT FLOWS THROUGH.

FUSE LINK WIRE


FUSIBLE LINK
CONNECTOR
SERVICE PACKAGE
THOROUGHLY TAPE ALL EXPOSED WIRES
CONNECTOR CRIMPED AND SOLDERED

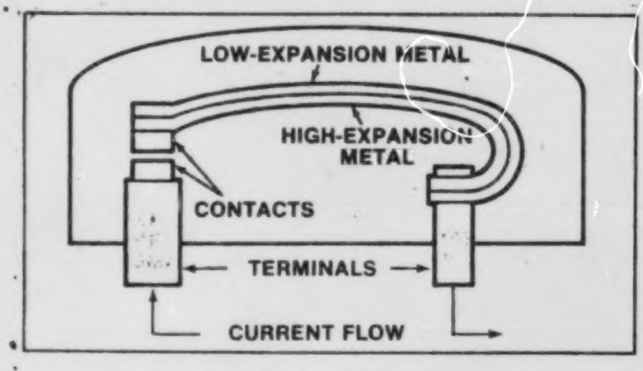
Installing New Fusible Link

CAUTION: Resistance wires, like fuse links, are also spliced into conductors in some areas. Do not make the mistake of replacing a fuse link with a resistance wire. Resistance wires are usually longer than fuse links and are stamped with printing, reading "RESISTOR- DO NOT CUT OR SPLICE."

Circuit Breakers

In certain curcuits which may sometimes undergo only temporary overloads, and in circuits where it is important to be able to restore power quickly (headlights, for instance), when a new fuse of fuse link may not be readily available for replacement, circuit breakers are installed.

Shown below is the construction of a typical self-resetting circuit breaker. The circuit breaker consists of two strips of metal which have different coefficients of expansion. As an overload of current flows through the bi-metallic strip the high-expansion metal will elongate due to heat and break the contact. Then, with the circuit open and no current flowing the high-expansion metal cools and shrinks; the bi-metal strip is drawn down again until contact is re-established. In actual operation, the contact is broken very quickly. If the overload is continuous, the circuit will be repeatedly broken and made until the source of the problem is corrected.


LOW-EXPANSION METAL
HIGH-EXPANSION METAL
CONTACTS
TERMINALS
CURRENT FLOW

TYPICAL CIRCUIT BREAKER CONSTRUCTION

This self-resetting type of circuit breaker is the type most generally used in automotive electrical systems. Manually resettable circuit breakers, however, are sometimes used. On manual types, a button will pop up on the circuit breaker case. The circuit breaker then is reset by pushing in the button.

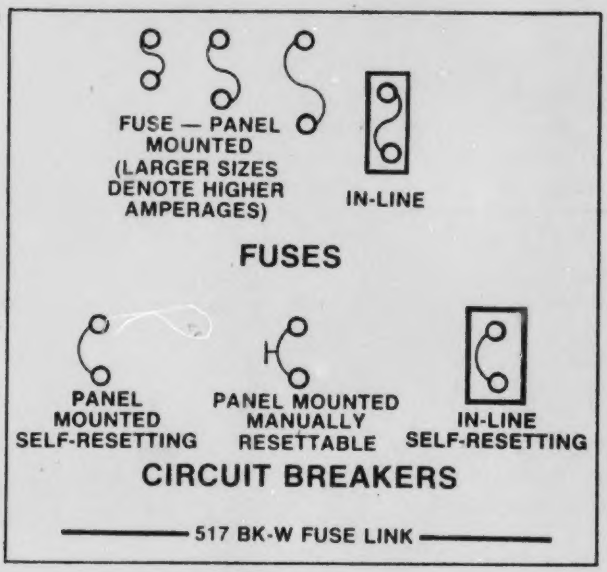
Circuit Protection and Diagnosis

Keep in mind that replacing a fuse or fuse link or resetting a circuit breaker does nothing toward remedying the problem that caused the overload. Indeed, the replacement or resetting may be fruitless because the fuse or circuit breaker will blow again as soon as the circuit is switched on. So, always repair the source of the overload before restoring the circuit protection device.

NOTE: In searching for overloads keep in mind that the circuit protection devices protect only against overloads downstream from the device; that is, overloads between the circuit protection device and the circuit ground.

Symbols and Designation

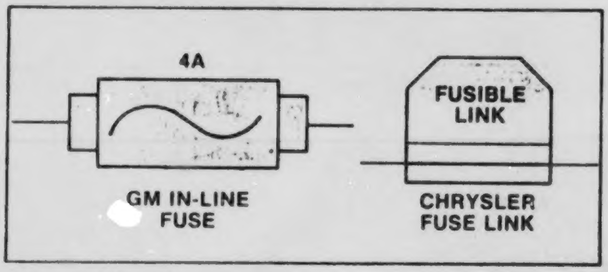
The symbols used on the wiring diagrams to designate circuit protection devices are shown below. Fuses and circuit breakers are designated on the diagrams by the letter "F" and number (F1,F2, etc.). Fuse link is designated by the circuit number and the words "FUSE LINK".


FUSE — PANEL MOUNTED (LARGER SIZES DENOTE HIGHER AMPERAGES)
IN-LINE
FUSES
PANEL MOUNTED SELF-RESETTING
PANEL MOUNTED MANUALLY RESETTABLE
IN-LINE SELF-RESETTING
CIRCUIT BREAKERS
517 BK-W FUSE LINK

FUSE, CIRCUIT BREAKER, AND FUSE LINK SYMBOLS

Related Information

The symbols for fuses and circuit breakers are fairly well standardized in the industry. Some differences exist in the manner in which in-line devices are drawn, however, as shown below.


4A
FUSIBLE LINK
GM IN-LINE FUSE
CHRYSLER FUSE LINK

TYPICAL GM AND CHRYSLER CIRCUIT PROTECTION SYMBOLS

Comparison Fuse Size Chart

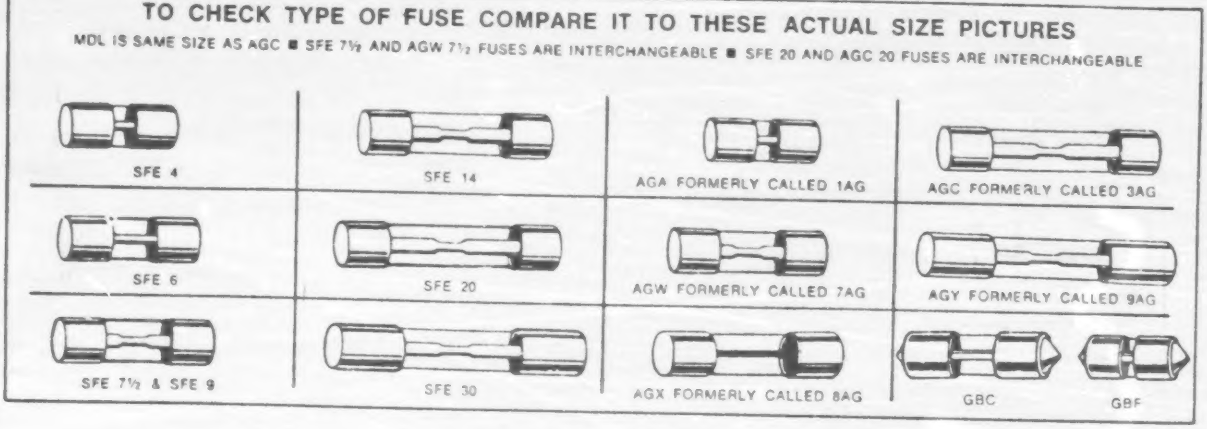
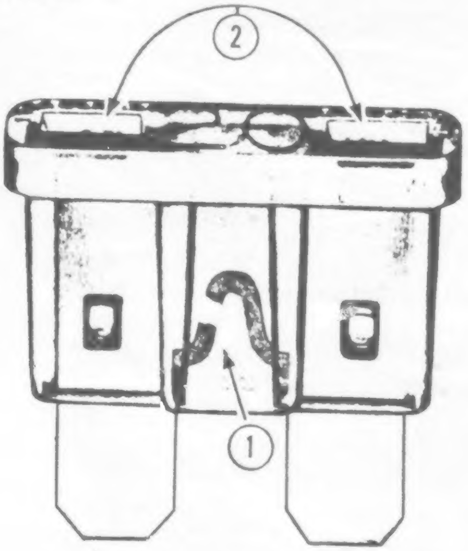

TO CHECK TYPE OF FUSE COMPARE IT TO THESE ACTUAL SIZE PICTURES
MDL IS SAME SIZE AS AGC ■ SFE 7½ AND AGW 7½ FUSES ARE INTERCHANGEABLE ■ SFE 20 AND AGC 20 FUSES ARE INTERCHANGEABLE
SFE 4
SFE 14
AGA FORMERLY CALLED 1AG
AGC FORMERLY CALLED 3AG
SFE 6
SFE 20
AGW FORMERLY CALLED 7AG
AGY FORMERLY CALLED 9AG
SFE 7½ & SFE 9
SFE 30
AGX FORMERLY CALLED 8AG
GBC
GBF

Fig. 4.14. Commonly found fuses that are shown in their actual size. These are the sentries of the electrical system along with circuit breakers.

Miniaturized Fuses
Direct Factory Replacement for all 1977 Full-Size Cars
Mini-fuse smaller, more compact, a completely new concept in fuse design. And it's the only fuse that will work in a 1977 full-size GM cars. In combination with GM's new miniaturized fuse block, the Mini-fuse delivers approximately twice the fusing capacity of present systems. Engineered for easy servicing and greater reliability, it plugs into the fuse block, quickly and easily. And it's just as easy to remove -- no bent clips, no broken glass. For easy identification, the amperage is clearly marked in large bold letters on the end of each fuse.



TO TEST FOR BLOWN MINI-FUSE:

① PULL FUSE OUT AND CHECK VISUALLY.
② USE A TEST LIGHT TO CHECK FOR CONTINUITY AS SHOWN.

MINI-FUSE COLOR CODES

RATING	COLOR
5 AMP	TAN
10 AMP	RED
20 AMP	YELLOW
25 AMP	WHITE

Wire Size

Cable size and length determines its resistance. The smaller the diameter of the wire or cable, the greater its resistance. Also, the longer the cable or wire, the greater its resistance will be.

Wire and cable sizes are expressed by a gauge number, which indicates the cross-sectional area (not diameter) of the conductor. The cross-sectional area of wires is given in circular mils. A circular mil is a unit of area of a circle one mil in diameter. A mil is a unit of length equal to .001 in. This a wire 10 mils in diameter has a cross-sectional area of 100 circular mils (or 78.54 sq. mils.

In the case of cables, which are made up of a number of strands of wire, the cross-sectional area of the cable is equal to the circular mil area of a single strand, times the number of strands.

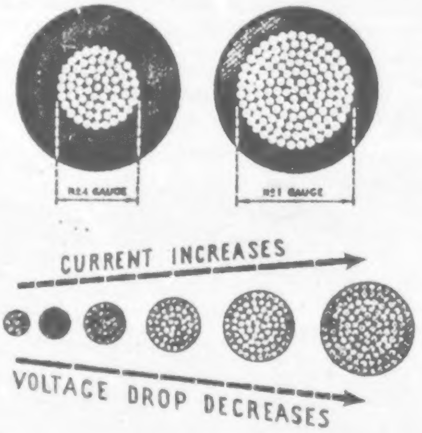
Special gauges, are available for measuring the gauge size of wires. If such gauges are not available, the diameter can be measured by means of a micrometer. Then by checking the diameter obtained in that manner with the accompanying wire table, its gauge size can be determined.

To determine the gauge size of a cable, count the number of strands. Then measure the diameter of a single strand with a micrometer. In the wire table, determine the area in circular mils for that diameter wire. Then multiply the area of the single wire in circular mils by the number of strands in the cable. Locate in the table the area in circular mils that is closest to that value. The gauge size corresponding to the total area in circular mils will be the gauge size of the cable.

When comparing cables it must be remembered that the external diameter of a wire or cable has nothing to do with its current-carrying capacity. Thick insulation will make a small gauge wire look much larger. It is therefore important that only the size of the metal conductors be compared, and the way to do that is by means of a wire gauge, or by a micrometer.

THE L.S. STARRETT CO
ATHOL MASS U.S.A.
AMERICAN STANDARD WIRE GAGE
Nº 281

Typical gauge used for measuring the size of wire.



Illustrating the gauge of electric cable and the effect of gauge size on voltage drop.

TYPICAL CIRCUIT CURRENT DRAWS AND RECOMMENDED WIRE GAUGE

		WIRE GAUGE (max. 10ft)	
ELECTRICAL EQUIPMENT	AMPS	12-Volts	6-Volts
Ammeter to Fuse Block	50	12	10
Back-up Lights	12-15	18	16
Battery to Ammeter	50	12	10
Cigar Lighter	20	16	14
Coil Wire (low tension)	20	16	14
Fuel Gauge	12-15	18	16
Gen/Alternator to Regulator	20	16	14
Gen/Alternator to Battery	50	12	10
Head Light Circuit	20	16	14
Head Light Relay	50	12	10
Heater to Fuse Block	20	16	14
Horn Button Circuit	20	16	14
Horn to Relay and Battery	50	12	10
Ignition Switch Feed	50	12	10
Instument Lamps	12-15	18	16
Interior Lights	12-15	18	16
Light Switch to Relay or Fuse	25-30	14	12
Marker (fender) Lights	12-15	18	16
Radio to Ammeter or Fuse	12-15	18	16
Parking/Direction Signals	12-15	18	16
Sending Units	12-15	18	16
Tail Lights/Stop Lights	12-15	18	16
Windshield Wiper and Washer	20	16	14

NOTE: The above recommendations are for typical circuits. Heavy-duty equipment will require heavier wire gauge.

WIRE GAUGE SELECTION

(1) Identify circuit current load (Ampere) requirements.

(2) Determine circuit length (feet) including ground wire if used.

(3) Determine wire gauge by locating AMPS and FEET intersection on chart.

WIRE GAUGE REQUIRED BY LENGTH IN FEET

6 VOLT	12 VOLT															
AMPS	AMPS	3'	5'	7'	10'	15'	20'	25'	30'	40'	50'	60'	70'	80'	90'	100
0.5	1	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
0.75	1.5	20	20	20	20	20	20	20	20	20	20	20	20	18	18	18
1	2	20	20	20	20	20	20	20	20	20	20	18	18	16	16	16
1.5	3	20	20	20	20	20	20	20	20	18	18	16	16	14	14	14
2	4	20	20	20	20	20	20	20	18	16	16	14	14	14	14	12
2.5	5	20	20	20	20	20	20	18	18	16	14	14	14	12	12	12
3	6	20	20	20	20	20	18	18	16	14	14	14	12	12	12	10
3.5	7	20	20	20	20	20	18	16	16	14	14	12	12	12	10	10
4	8	20	20	20	20	18	16	16	14	14	12	12	12	10	10	10
5	10	20	20	20	20	18	16	14	14	12	12	10	10	10	10	8
6	12	20	20	20	18	16	14	14	14	12	10	10	10	8	8	8
7.5	15	20	20	20	18	16	14	12	12	10	10	10	8	8	8	6
10	20	20	20	18	16	14	12	12	10	10	8	8	8	6	6	6
12	24	20	18	16	14	14	12	10	10	8	8	8	6	6	6	4
15	30	18	16	16	14	12	10	10	10	8	8	6	6	6	4	4
18	36	16	14	14	14	12	10	10	8	8	6	6	4	4	4	4
25	50	14	14	14	12	10	8	8	8	6	4	4	4	2	2	2
50	100	14	12	10	8	8	6	6	4	4	2	2	1	0	0	2/0
75	150	12	10	8	6	6	4	4	2	2	1	0	2/0	2/0	3/0	3/0
100	200	10	8	8	6	4	2	2	2	1	0	2/0	3/0	4/0	4/0	4/0

NOTE: WHEN MECHANICAL STRENGTH IS A FACTOR, USE NEXT LARGER WIRE GAUGE.

NOTE: THE ABOVE REPRESENTS A MAXIMUM 10% VOLTAGE DROP TOLERANCE. FOR 5% TOLERANCE REQUIREMENTS, CALCULATE CORRECT GAUGE BY USING DOUBLE THE NEEDED LENGTH.

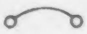
Electrical Competencies- Electrical Fundamentals

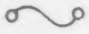
No. A - 5 How To Identify Components, Symbols, and Circuit Protection Devices

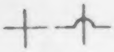
Worksheet # 1

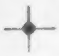
Name ________________________________ Date ____________ Grade ____________

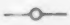
DIRECTIONS: In the spaces provided, place the most correct answer.

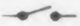
1.  ______

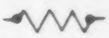
2.  ______

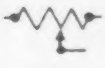
3.  ______

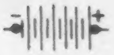
4.  ______

5.  ______

6.  ______

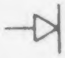
7.  ______

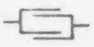
8.  ______

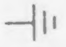
9.  ______

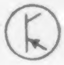
10. ______

11. ______

12.  ______

13.  ______

14.  ______

15.  ______

A. Resistor.

B. Circuit Breaker.

C. Wires Crossing - Not Connected.

D. Fuse.

E. Diode.

F. Wires Crossing - Connected.

G. Positive.

H. Terminal.

I. Switch.

J. Rheostat.

K. Transistor.

L. Battery.

M. Negative.

N. Condenser.

O. Ground.

16. The __________ ______protects a circuit from an overload.

17. Automotive wiring is ____________ coded.

18. No. 16 wire is smaller than No. 18 wire. True or False?

19. 12 volt wiring is of a heavier gauge than that for 6 volt. True or False?

20. As long as a terminal fits the stud or post, it is O.K. to use. True or False?

21. If, when joining wire ends, it is desirable to be able to disconnect them at a future date, a __________ type connector would be a good choice.

22. As long as a connection is tight, it will be a good conductor. True or False?

23. As long as the insulation is alright a wire can be considered O.K. True or False?

24. A frayed wire can cause a _________ circuit.

25. A corroded connection will increase ____________ to electrical flow.

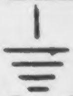
Instructor's Initials____________

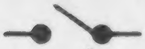
Electrical Competencies- Electrical Fundamentals

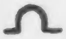
No. A - 5 How To Identify Components, Symbols
and Circuit Protection Devices

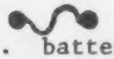
Test # 1

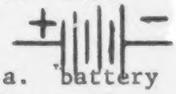
Name ________________ ____________ Date ________________ Grade ____________

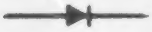
1.  is the symbol for:
   - a. ohms
   - b. ground
   - c. switch
   - d. fuse
   - e. diode

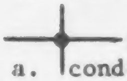
2.  is the symbol for:
   - a. ohms
   - b. ground
   - c. switch
   - d. fuse
   - e. diode

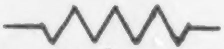
3.  is the symbol for:
   - a. ohms
   - b. ground
   - c. switch
   - d. fuse
   - e. diode

4.  is the symbol for:
   - a. battery
   - b. coil
   - c. switch
   - d. diode
   - e. fuse

5.  is the symbol for:
   - a. battery
   - b. coil
   - c. wires that cross-connected
   - d. diode
   - e. fuse

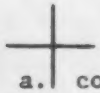
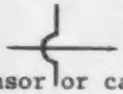
6.  is the symbol for:
   - a. battery
   - b. coil
   - c. switch
   - d. diode
   - e. terminal

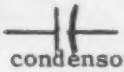
7.  is the symbol for:
   - a. condensor or capacitator
   - b. wires that cross-not connected
   - c. wires crossing-connected
   - d. terminal
   - e. resistor

8.  is the symbol for:
   - a. condensor or capacitor
   - b. wires that cross-not connected
   - c. wires crossing-connected
   - d. terminal
   - e. resistor

Electrical Competencies- Electrical Fundamentals

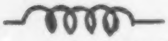
No. A - 5 How To Identify Components, Symbols
and Circuit Protection Devices

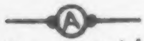
9.  or  is the symbol for:
   a. condensor or capacitor
   b. wires that cross-not connected
   c. wires crossing-connected
   d. terminal
   e. resistor

10.  is the symbol for:
   a. condensor or capacitor
   b. wires that cross- not connected
   c. wires crossing-connected
   d. terminal
   e. resistor

11. + is the symbol for:
   a. negative
   b. positive
   c. neutral
   d. coil (inductor)
   e. ammeter

12. — is the symbol for:
   a. negative
   b. positive
   c. neutral
   d. coil (inductor)
   e. ammeter

13.  is the symbol for:
   a. negative
   b. positive
   c. neutral
   d. coil (inductor)
   e. ammeter

14.  is the symbol for:
   a. negative
   b. positive
   c. neutral
   d. coil (inductor)
   e. ammeter

15. ———————— is the symbol for:
   a. generator
   b. positive
   c. spark gap
   d. a conductor
   e. male push-on conductor

16. A ____________________ may be used to prevent a circuit against an overload.
   a. transistor
   b. terminal
   c. splice
   d. fuse
   e. gage

17. A ___________ may be used to protect a circuit against short circuits.
    a. fuse
    b. circuit breaker
    c. fuseable links
    d. all of the above
    e. none of the above

18. A ___________ is a circuit protection device that is designed to melt and open the circuit before damage to the rest of the circuit can take place.
    a. circuit breaker
    b. rheostat
    c. fuse link
    d. condensor
    e. all of the above

19. The type of circuit protection device used in the automotive headlight circuit is a:
    a. circuit breaker
    b. rheostat
    c. fuse link
    d. condensor
    e. all of the above

20. Circuit protection devices protect only against overloads that are between the:
    a. power source and the circuit protection device
    b. circuit protection device and the circuit ground
    c. fuse box and battery
    d. head light and taillight circuits
    e. all of the above

21. What are the two locations of a brake switch?
    a. Brake line and brake petal.
    b. Master cylinder and brake linkage.
    c. Master cylinder and brake petal.
    d. Brake line and brake linkage.
    e. None of the above

22. What are the two locations of a neutral starting switch.
    a. Transmission and carburator linkage.
    b. Carburator linkage and shift linkage.
    c. Driveshaft and carburator linkage.
    d. Shift linkage and transmission
    e. All of the above.

23. How is the horn electrical circuit actuated when the button is pushed?

    a. By grounding the circuit
    b. By connecting the horn relay to the accessory terminal of the Ignition Switch.
    c. By connecting the horn to the coil terminal of the Ignition Switch.
    d. By connecting the horn to the possitive battery terminal and grounding the relay.
    e. Any of the above.

24. What are the parts which are assembled into a headlite?

    a. Lens and filament.
    b. Lens, filament, and reflector.
    c. Filament and bulb.
    d. Reflector, filament, and bulb.
    e. All of the above parts go into a seal beam unit.

25. The ways in which wires are color coded for a schematic diagram are:

    a. solid color
    b. base color with stripe
    c. base color with hashmark
    d. base color with dot
    e. all of the above

X

AUTO MECHANICS

Electrical Competencies

No. A- 6 How to use manuals for test and Electrical Information

OBJECTIVE: After completion of this exercise, the student will be able to locate test procedures and specifications from reference manuals.

EXPLANATION: Complete worksheet to instructor's satisfaction.

MATERIALS NEEDED: Appropriate service manual for vehicle of student selection.

TOOLS NEEDED:

References	Do
#1. p. 6-5	1. Read the assigned references.
#2. p.399-400	2. Read the information sheet.
#3. p. 452-456, p.460-463	3. Complete work sheet assignment
#4. p.431-434, p. 444	4. Check with instructor
#5. p. 523-528	
#6.	
#7.p.282-289	
#8. p.18-26	

Information Sheet # 1

Because of the complexity of the modern automobile obtaining and using the proper specificiaitons becomes critical for proper service of the vehicle. When manufactures manuals are available, they provide the most desirable and accurate source. When they are not available, as in the case in most garages, (except dealerships), information must be obtained from other manuals. The most common of these are the Motor Auto Repair Manual, the Chilson Auto Repair Manual, and National Service Data published by Michell Manuals Inc. In addition, much of the required material may be obtained from lubrication manuals, or specification charts supplied by ignition part manufactures.

Each manual has an introduction and index which guides the user in understanding the manual organization.It will save the individual much time if he reads and throughly understands this information before trying to use the manual.

Electrical Competencies - Electrical Fundamentals

No. A-6 How To Use Manuals For Test And Electrical Information

Worksheet # 1

Name ______________________________ Date ____________ Grade ____________

DIRECTIONS:

Using the appropriate reference sources, locate and record the following information in the spaces provided.

Vehicle Make ____________________ Model ______________ Year ____________

Engine Size ________________ cubic inch Engine Type __________________

Number of Cylinders __________ Horsepower __________ hp. W/Wo.Air Conditioning ______

Carburetor size ____________ bbl. Transmission Type __________________

List the Anti-pollution Equipment ______________________________________

____

1. Recommended spark plug make ______________________________
2. Recommended spark plug type ______________________________
3. Recommended spark plug gap ______________________________"
4. Distributor point gap (if applicable) ______________________________"
5. Distributor point spring tension ______________ oz. to ______________ oz.
6. Dwell angle (if applicable) ______________________________°
7. Firing Order ______________________________
8. Timing in degrees ______________________________
9. Timing mark location ______________________________
10. Basic idle r.p.m. ______________________________ r.p.m.
11. Ignition timing set-up procedures:

______________________ ______________________

______________________ ______________________

______________________ ______________________

Electrical Competencies - Electrical Fundamentals

No. A-6 How To Use Manual For Test And Electrical Information

Worksheet # 1
page 2

12. Direction of distributor shaft rotation ____________________

Centrifugal(MECHANICAL) Advance

13. Advance Starts (Low) . . . . . . __________° @ __________rpm

14. Intermediate Advance(s) . . . . __________° @ __________rpm

__________° @ __________rpm

__________° @ __________rpm

15. Full Advance . . . . __________° @ __________rpm

Vacuum Advance

16. Inches of Vacuum to Start Plunger __________"Hg

17. Advance Starts (starting point) __________° @ __________"Hg

18. Intermediate Reading(s) . . . . __________° @ __________"Hg

__________° @ __________"Hg

__________° @ __________"Hg

19. Total Vacuum Advance . . . . . __________° @ __________"Hg

20. Condenser Capacity . . . . . . ________mfd. to __________mfd.

Alternator and Regulator Specifications

21. Alternator Make . . . . ____________________

22. Alternator Model Number . . . . ____________________

23. Current Rating - amperes . . . . ____________________amps.

Volts . . . . ____________________Volts.

24. Field Current @______°F . . . . ____________________amps.

(Field Coil Draw) . . . . ____________________Volts.

No. A-6 How To Use Manual For Test And Electrical Information

Regulator Specifications

25. Regulator Model Number . . . . ____________________

26. Field Relay - Air Gap . . . . ____________________"

Point Gap . . . . ____________________"

Closing Voltage . . . . ____________________Volts.

° Engine R.P. M. (MOPAR Only). . . . . ____________________rpm

27. Voltage Regulator - Air Gap . . . . ____________________"

Point Gap . . . . ____________________"

Voltage @ ______________°F . . . . ____________________Volts.

Starting Motor Specifications

28. No Load Test ____________________amps.

____________________Volts

____________________R.P.M.

AUTO MECHANICS

Electrical Competencies- Electrical Fundamentals

No. A-7 How To Use A Test Light And A Continuity Tester

OBJECTIVE:

After`the completion of this exercise the student will be able to use a test light (circuit tester) and a self powered test light (continuity tester) to identify and correct open and short circuits.

EXPLANATION:

1. Pass writted test with ____% accuracy.
2. Diagnose problems on worksheet.

MATERIALS NEEDED:

Vehicles with electrical problem

TOOLS NEEDED:

Test light (circuit tester)
Self powered test light (continuity tester)

References	Do
#1. p. 6-10 & 6-11	#1. Read the assigned references.
#2. --	#2. Read the information sheets
#3. --	#3. Take written test
#4. --	#4. Check with instructor.
#5. --	#5. Complete worksheet assignment
#6. --	#6. Check with instructor.
#7. --	
#8. p. 110-112 & 144-152	

No. A - 7 How To Use A Test Light And A Contiuity Tester

Information Sheet # 1

AN OPEN CIRCUIT IS "DEAD"

Open circuit are usually very easy to identify. There are no exotic effects, such as sparks flying or strange odors Simply stated, when you operate the switch, nothing happens. The circuit is just "dead".

What Causes Them to Open

Circuits become open for various reasons:

1. The ground is loose, corroded or disconnected. (Statistics show that 4 out of 10 electrical problems can be fixed by proper grounding.)

2. A wire is broken or loose from a terminal.

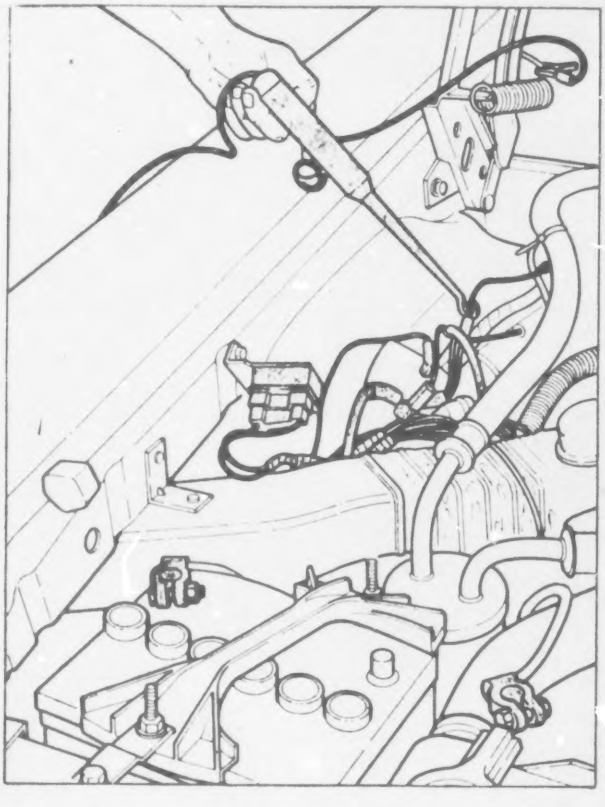
3. A connector is broken, separated or corroded.

4. The switch is faulty and won't connect the contacts.

5. The lamp filament or other load component is open or burnt out.

6. The circuit protector has opened due to a "short" to ground or an overload in the circuit.

The good news about open-circuit testing is that it's so easy; and three-fourths of the problems you'll diagnose are open circuits. Also, the test equipment is simple. You need nothing but jumper wires and a test light. The biggest difficulty you'll have, if you learn this technique, is with hard-to get at places. But we'll show you how to avoid them whenever possible.



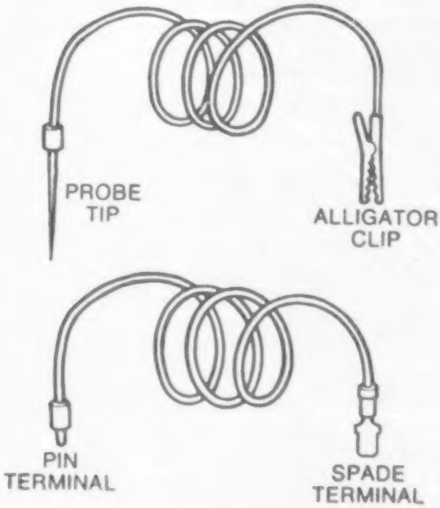
JUMPER WIRE

There are three quick-diagnosis tricks you can perform with a jumper wire:

1. Connect it between the load and a known good ground to see if grounding is the problem.
2. Connect it between the load and a known "hot" terminal to see if the load is operating.
3. Connect it to by-pass any part of length of the circuit that's suspected of being open. If the circuit works, the open point is in the part of the circuit you bypassed.

Every experienced electrical diagnostician has a variety of jumper wire lengths and terminals.

JUMPERS NEED A VARIETY OF TERMINALS



Alligator clips for attachment to pin or open terminals.

Spade and pin ends to insert into recess sockets.

A probe tip (or and awl to clip the jumper to) for getting into tight places or through insulation to a wire.

CAUTION: Be sure your jumper is as heavy as the wire in the circuit. It will heat up if you make it handle too much electricity.

CAUTION: Never use a jumper wire to bypass the load, (light, motor, etc.).

12-VOLT TEST LIGHT

The test light is used to test for power; that is, to see if the circuit is "hot" at the test point.

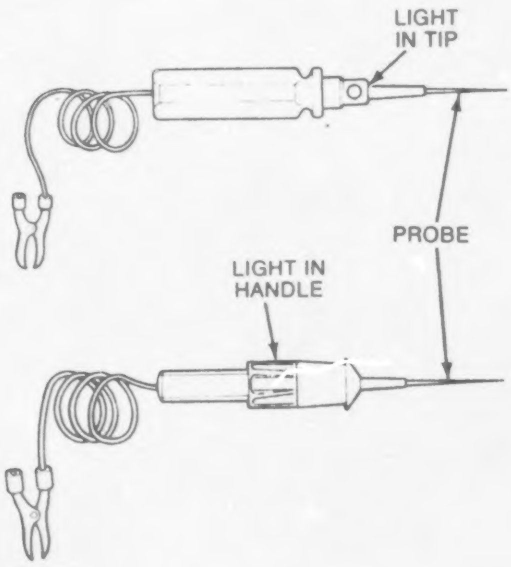
To use it, just clip the lead wire to any good ground and touch the probe tip to the test point. If the test point is hot, you'll complete a circuit through the tester and the lamp will glow.

If there's no glow, the circuit is open between the test point and the battery. You can pinpoint exactly where by simply checking at succeeding points along the circuit.

Test the tester before using it by touching its terminal to the battery posts.

This kind of test lamp has a sharp probe tip os you can insert it through insulation to test if a covered wire is hot. Be careful when you do this; or expect to stab yourself a few times until you get the "hang" of it.

TYPICAL PROBE-TYPE TEST LIGHTS

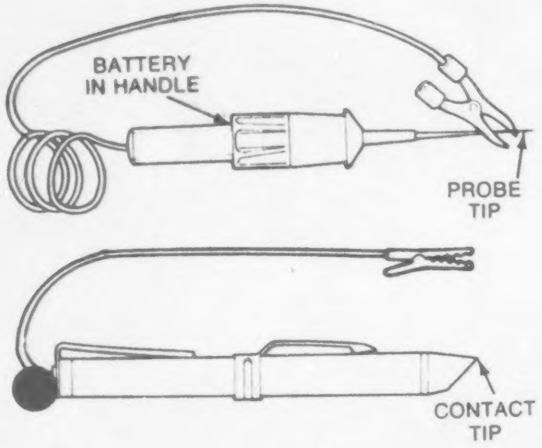


"WRAP-AROUND" TEST LIGHT

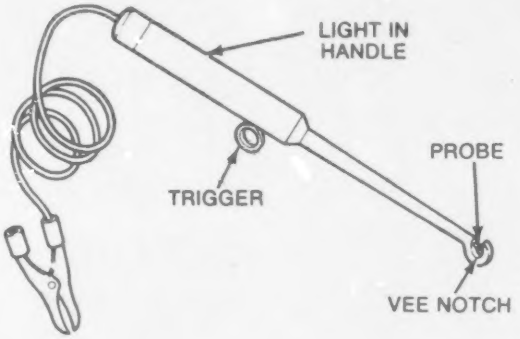
A "wrap-around" test light works on the same principle as the 12-volt test light. It's especially handy for tesing at wires in hard-to-get-at places, such as behind the dash.

To use it, ground the lead wire. Hook the vee notch over the wire being tested and pull the trigger. The probe tip will puncture the wire, and the handle will light up if the wire is "hot."

CONTINUITY TESTER


BATTERY IN HANDLE
PROBE TIP
CONTACT TIP

WRAP-AROUND TEST LIGHT


LIGHT IN HANDLE
TRIGGER
PROBE
VEE NOTCH

SELF-POWERED TEST LIGHT (CONTINUITY TESTER)

The self-pwered test light carries its own battery. It is used to test for continuity through a component or a part of the circuit. Whatever is being tested must be isolated from the battery. If you connect this tester to 12 volts, its 1½ volt bulb will burn out.

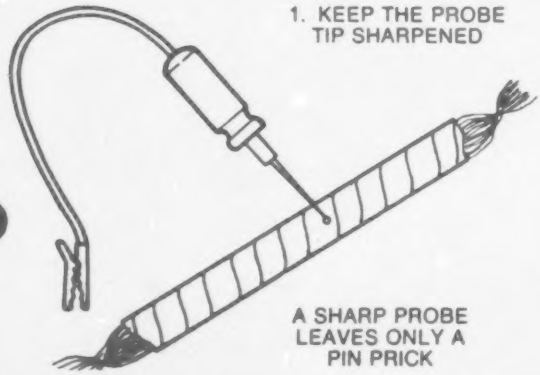
TESTING THE TESTER.

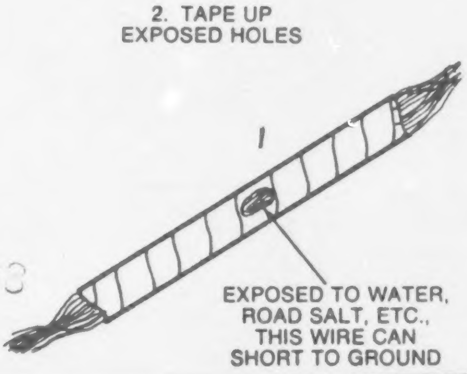
To be sure the self-powered light is operationg, touch the end of the lead to the tip of the probe or the contact tip. If the tester is okay, the light will come on. If it doesn't, check the battery and the bulb.

TESTING FOR CONTINUITY

Clip or touch the tester lead to one end of the component or section of the circuit, and touch the tip to the other. If there's continuity, you'll complete a circuit and the light will come on.

IMPORTANT . . . TO PREVENT SHORT CIRCUITS


1. KEEP THE PROBE TIP SHARPENED
A SHARP PROBE LEAVES ONLY A PIN PRICK


2. TAPE UP EXPOSED HOLES
EXPOSED TO WATER, ROAD SALT, ETC., THIS WIRE CAN SHORT TO GROUND

Left Headlamp Out

This problem occurred on a Pinto, but can happen in any headlight circuit. The repair order said: "fix the headlights." It might just as easily have said "replace left sealed beam" if the service advisor fancied himself a diagnostician. It's another example of how proper diagnosis pays off in getting the job done right the first time.

What Makes A Bulb Dim?

There are three most common causes of a bulb operating dimly (or a motor running slowly or a horn beeping weakly or any other load component doing only a partial job). In the order of likelihood, they are:

1. The ground is bad (poorly connected),or the ground is open and the load is grounding through some other load operating in parallel with it.
2. There is a poor connection somewhere in the hot circuit which is "starving" the load of the electricity it needs to operate fully.
3. The load component itself is faulty.

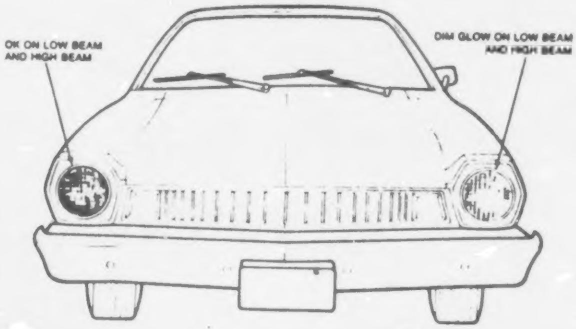
There are other more exotic causes we'll deal with later. For now, let's see how open-circuit testing will diagnose the most frequent causes.

Step 1. Determine the Problem

Driving into the stall, the technician determined the problem by turning on the headlight switch and hitting the dimmer switch. The right sealed beam threw a light against the wall on both high beam and low beam. The left sealed beam appeared out.

Leaving the headlamp switch on, the technician looked at the left sealed beam up close. He saw a faint orange glow on both the high and low beam positions of the dimmer switch.

This is a common problem, and it's easy to miss the faint glow. You could easily conclude that a new sealed beam will fix the problem- and be dead wrong!


OK ON LOW BEAM AND HIGH BEAM
DIM GLOW ON LOW BEAM AND HIGH BEAM

Step 2. Trace the Circuit

We really need to trace only a small part of the headlamp circuit to diagnose this problem. But it's good to understand the entire circuit for other problems. So we'll "walk" all the way through it, again starting at the battery. (see next page).

1. The battery positive cable feeds the main hot terminal at the starter relay.
2. Wire 37 yellow continues the circuit through a splice or two, and through the dash panel connector, to the headlamp switch connector. At the headlamp switch, we come to a "common point".
3. Inside the switch are two circuit breakers, both fed from wire 37Y. (There is no fuse in the headlamp circuit.)

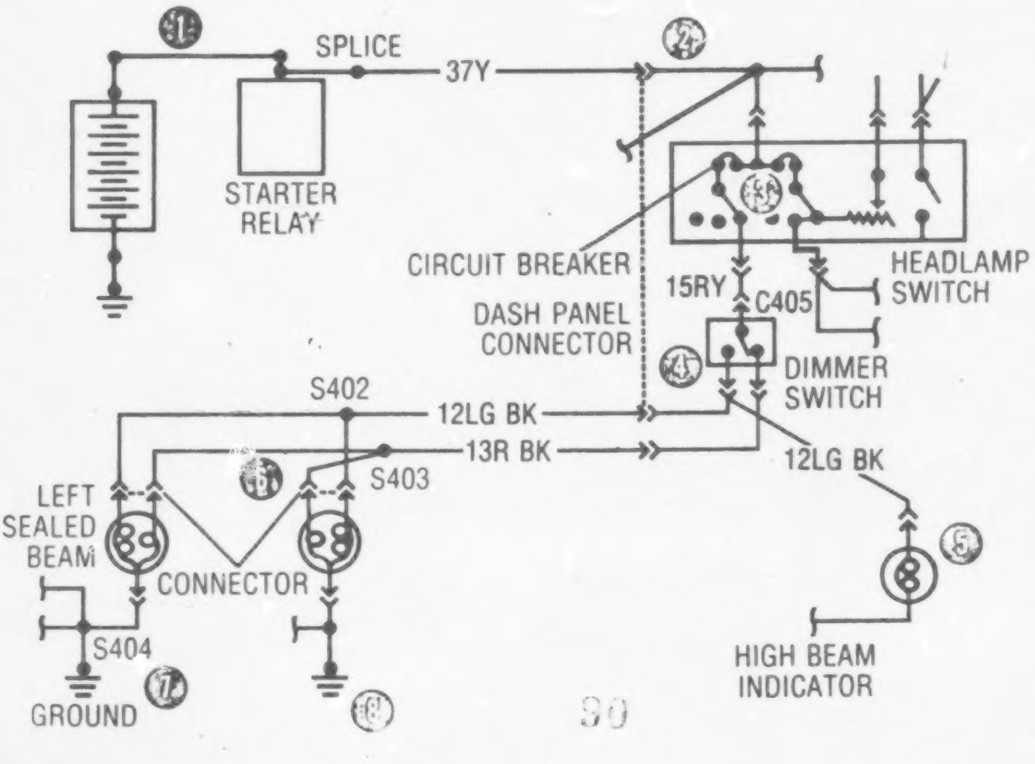
The running lamp breaker protects the parking and marker lamp circuit and the instrument panel circuit from overload. Both of these circuits are fed from a second set of contacts in the switch in either the park or headlamps-on position. So if any marker or instrument lamp works, there is power as far as the headlamp switch.

In the headlamps-on position only, power continues through the switch and its connector via wire 15 red,to the dimmer switch connector C-405.

4. The dimmer switch is a common point for high beams and low beams. If either high or low beam works, we know there is power as far as the dimmer switch.
5. In the high beam position, the dimmer switch feeds the high beam filaments in the sealed beams through splice S-402 and it also feeds the high beam indicator light wire 12 (light green).
6. On low beam, wire 13 red (with black stripe) powers the low beam filaments. It is "split" at splice S-403, just as the high beam wire is split at S-402.
7. Both filaments of the left sealed beam are grounded through splice S-404 in the wiring harness. The left parking and marker lamp ground wires also are connected to this splice. A single black wire goes from the splice to a ground screw near the parking lamp.
8. The right sealed beam also is grounded in common with the "running" lamps on the right side of the car.

Dual Headlamps

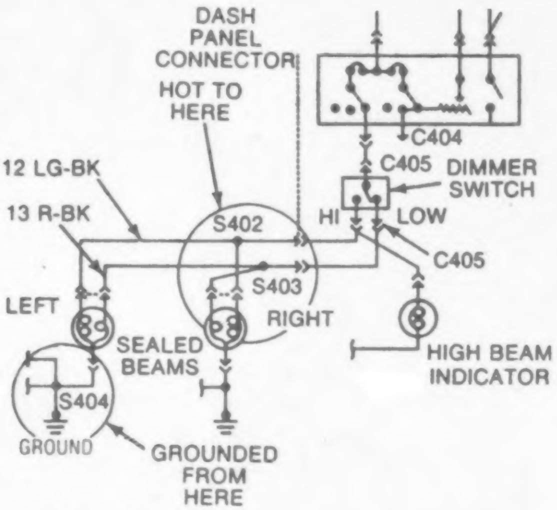
If the car has dual headlamps, the wiring is the same to the high-low sealed beam. Wire 13 red also continues to the low sealed beams, and they are grounded at the same points just described.


1
SPLICE
37Y
2
STARTER RELAY
3
CIRCUIT BREAKER
HEADLAMP SWITCH
15RY
C405
DASH PANEL CONNECTOR
4
DIMMER SWITCH
S402
12LG BK
13R BK
12LG BK
S403
6
LEFT SEALED BEAM
CONNECTOR
5
S404
7
GROUND
8
HIGH BEAM INDICATOR

Step 3. Isolate the Problem
Common point diagnosis is a big help in this problem.

1. Because both the high and low beams work on the right side, we know that the circuit is hot up to splices S-402 and S-403.
2. We look at the parking lamp and find it is okay. That tells us the ground circuit is okay from S-404 to the ground terminal.

The trouble is somewhere in the area marked in red; between the "okay" common points.



ISOLATION

DASH PANEL CONNECTOR
HOT TO HERE
12 LG-BK
13 R-BK
S402
S403
C404
C405
DIMMER SWITCH
HI
LOW
C405
LEFT
SEALED BEAMS
RIGHT
HIGH BEAM INDICATOR
S404
GROUND
GROUNDED FROM HERE

Step 4. Test Systematically
Now it's necessary to get at the terminals on the sealed beam. On the car illustrated, we have to pull the rim and free the sealed beam. On others, you can get to the connector easily with the hood up.

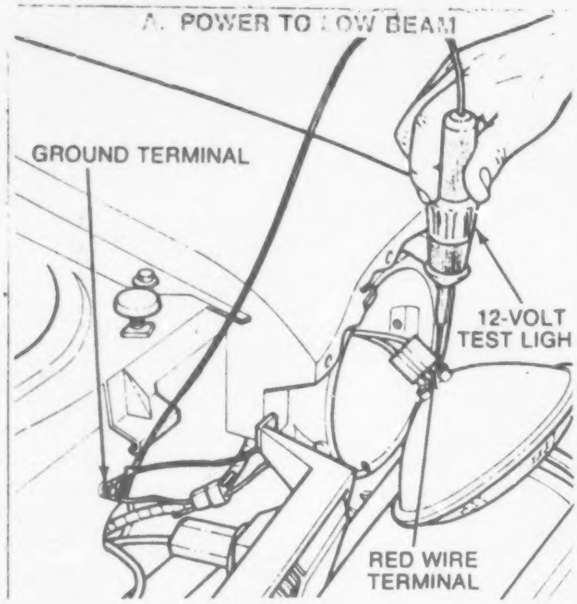
Test A. Clip the lead of a 12-volt test light to the ground and check for power at the low beam (red wire) terminal of the sealed beam. The dimmer switch must be on low beam, of course.
Results. The test light glows brightly.
Conclusion. Circuit 12 is okay up to the sealed beam.

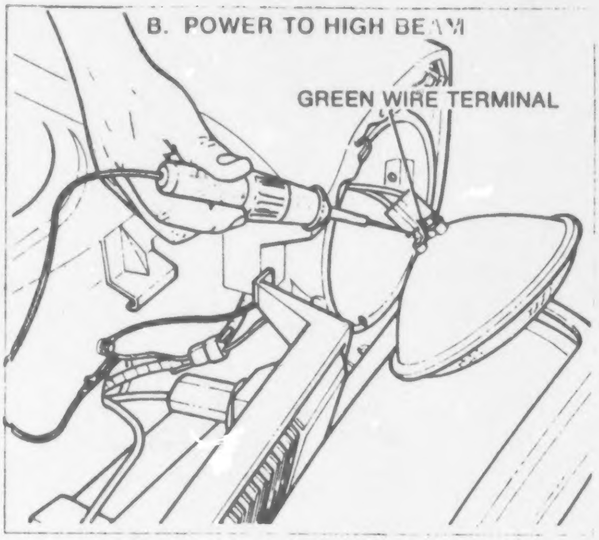
(If the test lamp was dim, we'd suspect a bad connection. Since it's bright, we conclude no problem up to this point).

(See picture on following page.)

Test B. Kick the dimmer switch to high beams and test for power at the green wire terminal.
Results. The test lamp glows brightly.
Conclusion. Both power circuits are okay up to the sealed beam. The problem has to be a bad ground or a bad sealed beam.

Obviously, it's a lot easier to check the ground than to go get a new sealed beam. So ...

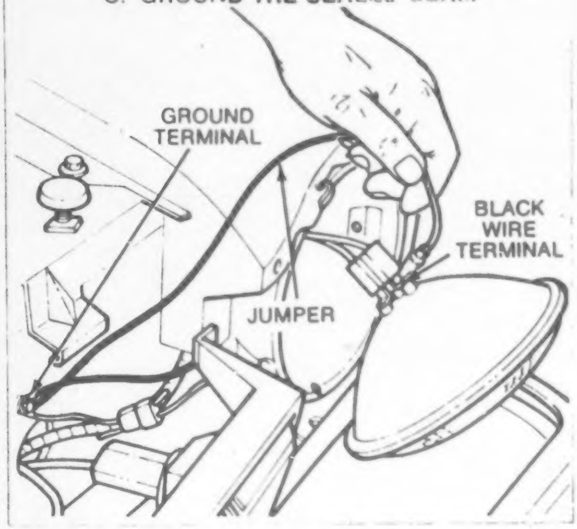




Test C. Connect a jumper wire from the black wire terminal on the sealed beam to ground.
Results. The sealed beam works perfectly on both high and low beam.
Conclusion. The ground wire connection is bad or open between the black wire terminal and splice S-404.

About That Dim Glow...
The headlamp will glow dimly with a bad or open ground, because there is a ground path through the opposite beam. For instance, on low beam, the ground path is through the high beam filament, then through wire 12 to the right hand beam and through its high beam filament to ground.

The filaments offer enough resistance to prevent the low beam from operating at full brightness.

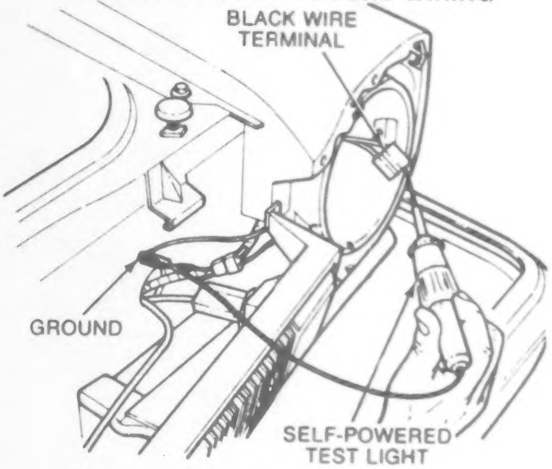


C. GROUND THE SEALED BEAM

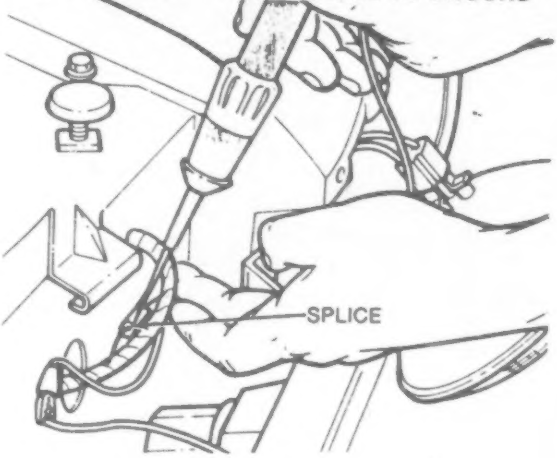
We have determined that the left headlamp ground is open somewhere between the sealed beam and the ground splice. To try to pinpoint it, we will use a self-powered test light with a probe tip for a couple of continuity checks. We'll turn the headlamp switch off to isolate the circuit from power. Also, we will unplug the sealed beam so that the "alternate" ground path is out of the circuit.

Test D. Clip the lead of the test light to the ground terminal and touch the probe to the black wire terminal of the headlamp connector. Also insert the probe tip into the wire near the connector.
Results. No continuity to ground. (If the test light went on, we'd have pinpointed the problem to the connector terminal.)

D. CONTINUITY OF GROUND WIRING



E. CONTINUITY FROM SPLICE TO GROUND



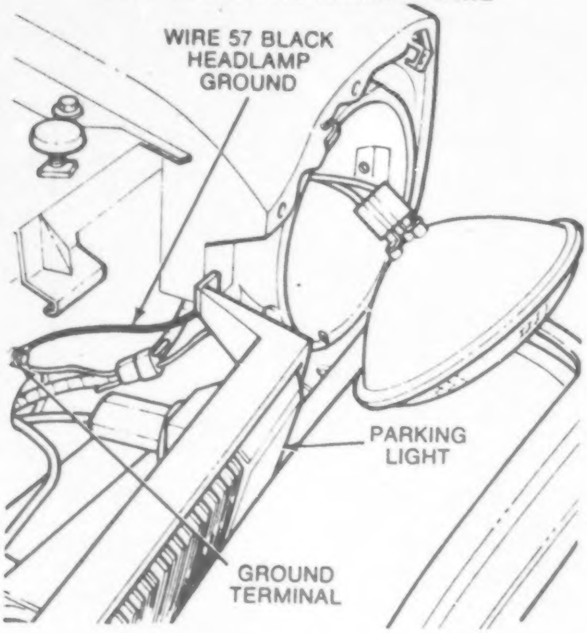
Test E. Insert the tester probe into the headlamp ground wire where it enters the splice.
Results: No continuity to ground.
Conclusion: The headlamp ground wire is not making contact within the splice. (If it were, the tester would light; since we know there is continuity from the splice to ground.)

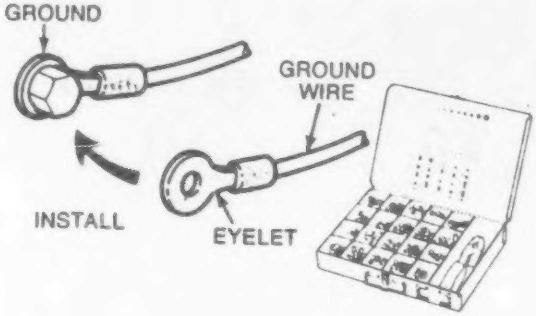
We have pinpointed the problem. Let's verify it.

Step 5. Verify the Problem
For the final diagnosis, turn the headlamp switch back on. And clip the headlamp ground wire from the splice with side-cutters.

Test F. Touch the bare end of the wire to ground.
Results. The headlamp works okay.

F. GROUND THE GROUND WIRE





Step 6. Repair
To repair the circuit, install a crimp-on eyelet on the ground wire and attach it to the ground terminal screw.

Step 7. Test the Repair
Then try the headlights one final time on high beam and low beam. They work okay... problem corrected by systematic testing and a very simple fix.

Systematic Testing Saves "Face"

This problem was chosen for an example because about 40 % of electrical failures are caused by poor grounds. Systematic testing avoided replacing the load component unnecessarily, which could cause "egg on the face" when you have to take the part back to the parts department.

Don't Forget
For a circuit to operate, three things are necessary:
1. There must be power to the load.
2. The load component must be okay.
3. The circuit must have continuity from the load to ground.

Be sure that your systematic diagnosis covers all three factors.

No. A - 7 How To Use A Test Light And A Continuity Tester

Information Sheet # 2

Short Circuits Are "Live"

When we speak of "short" circuits, we are talking about a condition where a "hot" conductor is touching something it shouldn't be. In other words, we've lost our insulation. We may also find that the circuit goes "dead" if the fuse or fuse link blows. But this time, we're still dealing with a "live" circuit (too live, in fact).

We'll cover three kinds of short circuits in this section:
1. A "dead" short to ground. A "hot" conductor is grounded directly to the chassis or a ground wire, so that it provides a "low-resistance" path for electricity when the wire is hot. This type of short always opens the circuit protector.
2. An "intermittent" short to ground. A hot conductor is bare and touches ground when it is bounced or jiggled.
3. A "cross-circuit" short. Two hot feed wires are crossed, and both circuits operate when you close the switch for only one.

A fourth type of short, a "high-resistance" short to ground, may not blow the fuse or breaker. Rather, it will drain the battery, since it doesn't draw enough electricity to "overload" the wire. This type of short circuit is diagnosed with an ammeter, which is covered in the final section.

Shorts to Ground in Breaker-Protected Circuits

If there's a short to ground in a circuit protected by a breaker, you may hear the breaker click on and off rhythmically. It opens when overheated, then cools and closes again momentarily. The load component may or may not operate when the circuit is closed, depending on resistance factors in the circuit.

A special case is the headlamp switch, which has two breakers in parallel from a common feed. One breaker is in the headlamp circuit, the other feeds the parking lamps and instrument panel lamps. (It may also feed the stoplamps and horn on some cars.) If one of these circuits is shorted to ground, it will also affect the parallel circuit. For instance, a short in the headlamp wiring would cause the parking and instrument panel lamps to flash bright and dim as the headlamp breaker opens and closes.

Short Circuit Test Equipment

Diagnosing a short to ground requires conecting some kind of tester between the circuit and ground,and testing for continuity to ground. The standard tester is the self-powered test light.

Diagnosing With Self-Powered Test Light

To diagnose a short to ground with the self-powered test light:
1. Isolate the circuit from power and ground. (For instance, remove the fuse and the bulb.)
2. Connect the test light between the circuit and ground at any convenient test point The light will glow if the circuit is grounded.
3. Open connectors one at a time until the light goes out. The short is beyond the last connector you opened.
4. Test in the isolated section of the circuit and/or inspect vusually to pinpoint the short.

No. A-7 How To Use A Test Light And A Continuity Tester

Information Sheet #2
Page 2

Home Made "Loud" Test Light

A more convenient short-circuit tester is what we call a "loud test light". You can make this yourself with a sealed beam, a flasher or 7-amp circuit breaker, and some wire.

1. Connect one test lead to the ground terminal of the sealed beam. (If you can get ahold of a sealed-beam connector, it will make repair of the tester simpler if the sealed beam burns out.)
2. Wire the high beam and low beam terminals together and attach a second test lead.
3. Connect the flasher or breaker in series with the sealed beam.
4. It is also desirable, but not necessary, to connect a buzzer in parallel with the flasher. Also, an on-off switch in one of the buzzer leads will make its signal optional during testing.
5. Make yourself various adapters from old wiring harnesses so you can connect the testerleads into circuits at the fuse panel, connectors, etc. It's also desirable to mount the tester components in a box (see below) for convenience and to prevent damage.

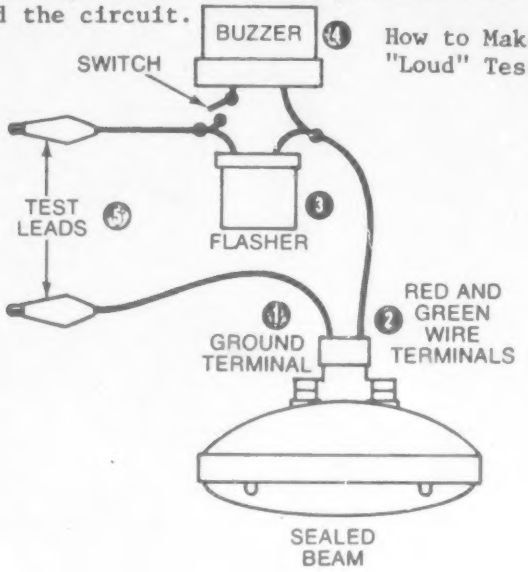
How To Use the "Loud" Test Light

To use this tester, you connect it in series with the circuit you're testing, and use battery power to "feed" it. When the circuit is closed and full power is supplied, the sealed beam will flash on and off brightly. Also it will buzz intermittently if you have the buzzer connected and turned on.

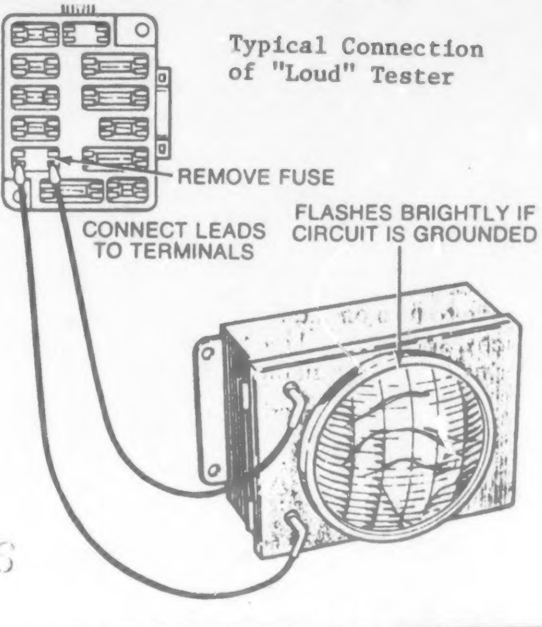
There are two big advantages to using this device:

1. You can hook it up and leave your hands free to work. Even at the other end of the car from where you're working, it will "tell" you plainly what's going on in the circuit.
2. You don't have to isolate the circuit from ground. If the test lamp grounds through the load, it will flash very weakly and just barely buzz. If it grounds through a dead short, it will signal loud and clear. There's no mistaking the difference.

However, remember that the self-powered test light could be used also. Or a 12-volt test light could be used, provided it's connected in series with the battery and the circuit.



How to Make a "Loud" Test Light


REMOVE FUSE
CONNECT LEADS TO TERMINALS
FLASHES BRIGHTLY IF CIRCUIT IS GROUNDED

Typical Connection of "Loud" Tester

Problem- Dome Light Doesn't Work

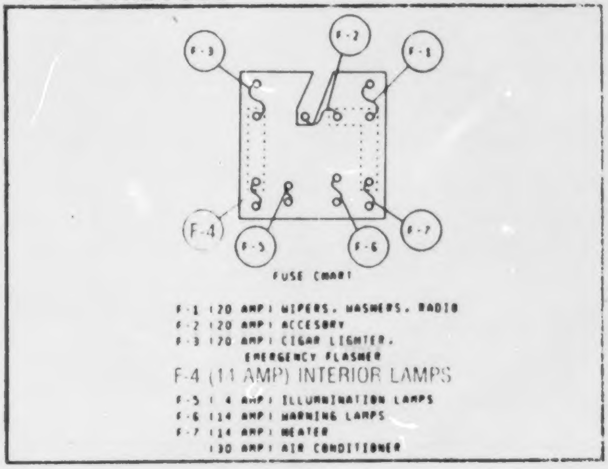
This problem occurred on a Maverick, but the circuits involved are just about the same on all car lines. The R.O. read: "Dome light doesn't work, third complaint. Fuse was replaced on (two earlier dates)". This note helps us to go beyond replacing the fuse, to also locate the cause of the fuse blowing.

Step 1. Determine the Problem

To determine the problem, open the driver's door. The door jamb switch closes, but the dome light doesn't come on.

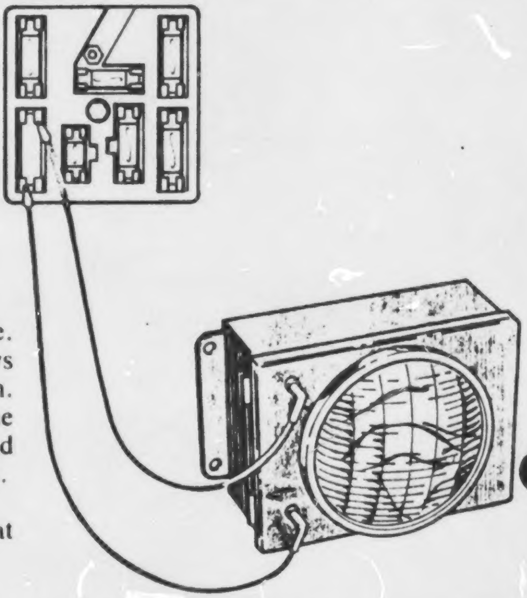
Next, check the fuse. The wiring diagram identifies fuse number four for the interior lamps. Pull it out and observe that it is blown.

CHECK THE FUSE


F-3
F-2
F-1
F-4
F-5
F-6
F-7
FUSE CHART
F-1 (20 AMP) WIPERS, WASHERS, RADIO
F-2 (20 AMP) ACCESORY
F-3 (20 AMP) CIGAR LIGHTER,
EMERGENCY FLASHER
F-4 (14 AMP) INTERIOR LAMPS
F-5 (4 AMP) ILLUMINATION LAMPS
F-6 (14 AMP) WARNING LAMPS
F-7 (14 AMP) HEATER
(30 AMP) AIR CONDITIONER

Let's presume you don't have a spare fuse, or you don't want to waste it in testing. We have been working with an excellent fuse substitute for short circuit testing. So ...

CONNECT THE LOUD TEST LIGHT



So we'll connect the loud test light in place of the fuse. With the test light installed, we observe that it glows faintly and buzzes softly with the driver's door open. This tells us that the circuit is grounding through the dome light and courtesy lights. But there's no dead short in the circuit yet, or it would be glowing brightly.

So it's time to consult the wiring diagram and see what else is on this fuse.

Step. 2 Trace The Circuit

To trace this circuit, we first went to the power distrubution page of the diagram and located fuse #4.
1. The fuse is battery hot, fed from the starter relay main feed terminal. It protects all the circuits powered by wire 54 LG-Y (light green with yellow tracer).
2. Wire 54 is marked in green on our schematic. There are two branches from the fuse terminal. One branch is connected to the right-hand door jamb switch (if the car is so equipped).

The other branch of wire 54 goes to:
3. The power-in terminal of the rotary courtesy lamp switch in the headlamp switch assembly...
4. The power-in terminal of the overhead dome lamp switch, if the car is so equipped...
5. The power-in terminal of the driver-side door jamb switch...
6. A connector that continues circuit 54 to the rear to power the luggage compartment lamp...
7. And finally to the glove box lamp and switch assembly.

Now let's follow wire 53 black, which powers the courtesy and dome lamps when one or more of the switches are closed:

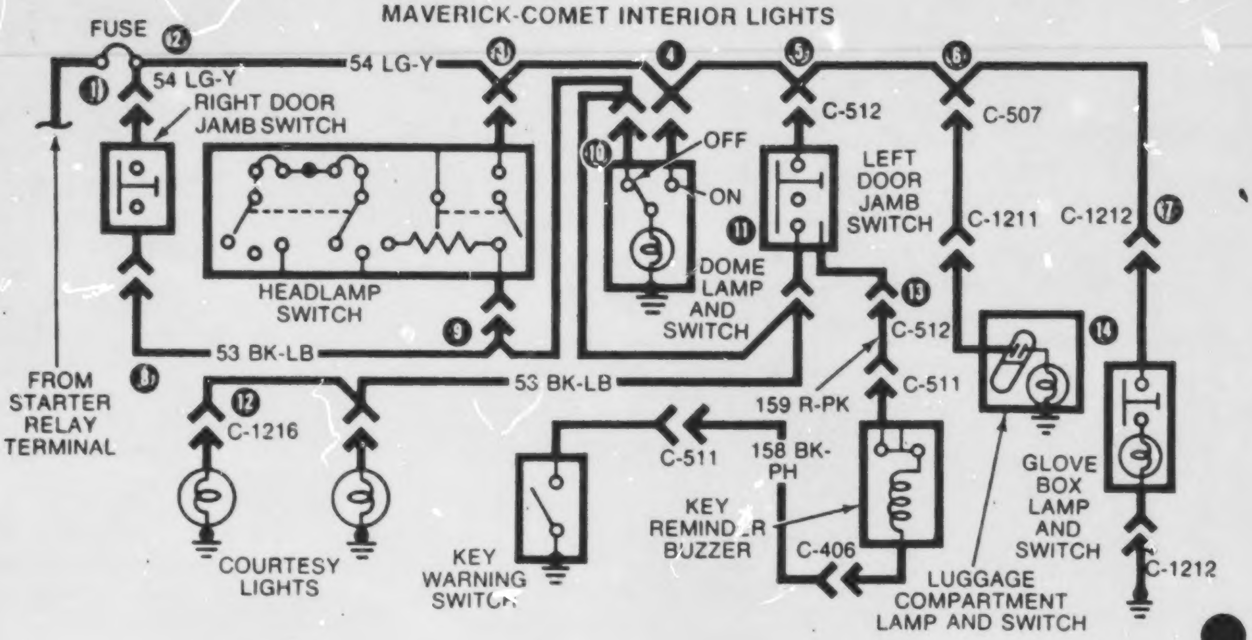
8. From the power-out terminal of the right door-jamb switch...
9. To the power-out terminal of the rotary switch...
10. To the dome lamp...
11. To one power-out terminal of the driver's door jamb switch...
12. And to the right and left hand courtesy lamps.

With this arrangement, the dome lamp and the courtesy lamps are on whenever any one of the switches is closed.

13. Notice that the left door jamb switch has an extra power-out terminal. This powers the key reminder buzzer circuit. The buzzer will sound when the door jamb switch closes and the key warning switch closes to ground the circuit.
14. The luggage compartment lamp and glove box lamp systems are independent of the courtesy light controls. They just happen to be powered by the same fuse. Of course, either one of them could be the culprit in this problem.

Incidentally, on earlier models, circuit 54 also feeds the seat belt warning module; another possible culprit in a similar problem.

MAVERICK-COMET INTERIOR LIGHTS


FUSE
54 LG-Y
54 LG-Y
RIGHT DOOR JAMB SWITCH
HEADLAMP SWITCH
53 BK-LB
53 BK-LB
FROM STARTER RELAY TERMINAL
C-1216
COURTESY LIGHTS
OFF
ON
DOME LAMP AND SWITCH
C-512
LEFT DOOR JAMB SWITCH
C-507
C-1211
C-1212
C-512
C-511
159 R-PK
C-511
158 BK-PH
KEY WARNING SWITCH
KEY REMINDER BUZZER
C-406
LUGGAGE COMPARTMENT LAMP AND SWITCH
GLOVE BOX LAMP AND SWITCH
C-1212

Step. 3 Isolate The Problem

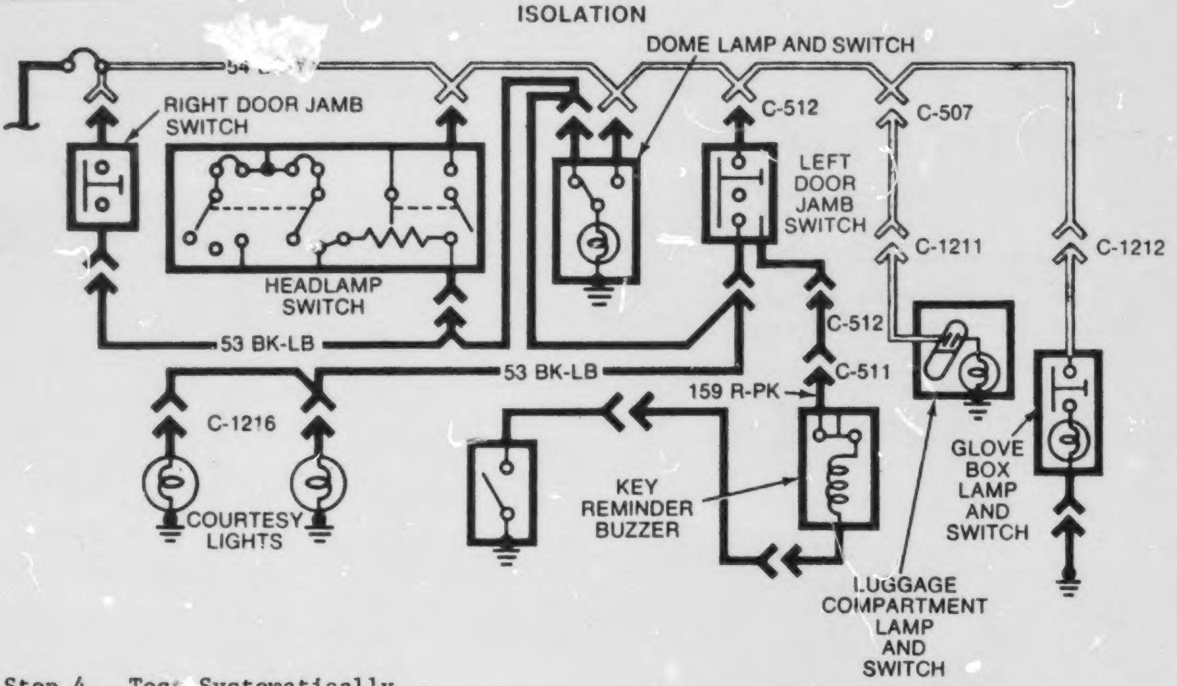
To proceed with isolating the problem, we turn on all the switches one at a time, and watch the tester. Start by opening the driver door and inserting the ignition key to activate the buzzer circuit. Also open the right door, the glove box and the trunk. Turn the headlamp switch knob to on, and the overhead dome lamp switch to on.

In each case,all we got on the tester at this point was dull glow; no indacation of a dead short. But since the fuse has blown twice before, we suspect an intermittent short. There must be a bare wire somewhere that touches ground when the car goes over a bump or vibrates.

Isolate to Circuit 54

We'll assume, then, that the fuse is blowing when the car is being driven. If so, all the switches are open (off) when the short occurs. Thus, we suspect that the bare wire is somewhere in circuit 54, ahead of the switches. (We have marked this in gray on the diagram below).

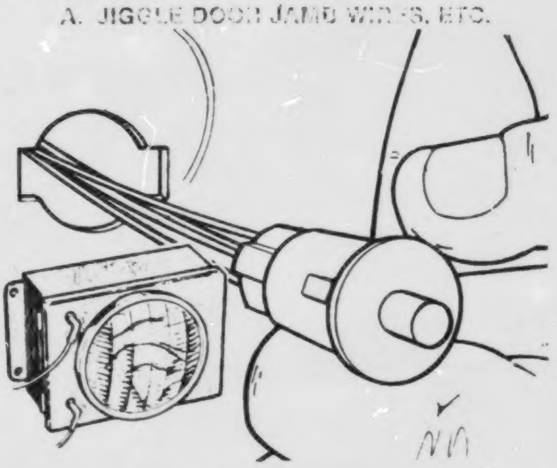
No. A-7 How To Use A Test Light And A Continuity Tester


ISOLATION
54
DOME LAMP AND SWITCH
RIGHT DOOR JAMB SWITCH
C-512
C-507
LEFT DOOR JAMB SWITCH
C-1211
C-1212
HEADLAMP SWITCH
53 BK-LB
C-512
53 BK-LB
C-511
159 R-PK
C-1216
GLOVE BOX LAMP AND SWITCH
KEY REMINDER BUZZER
COURTESY LIGHTS
LUGGAGE COMPARTMENT LAMP AND SWITCH

Step 4. Test Systematically

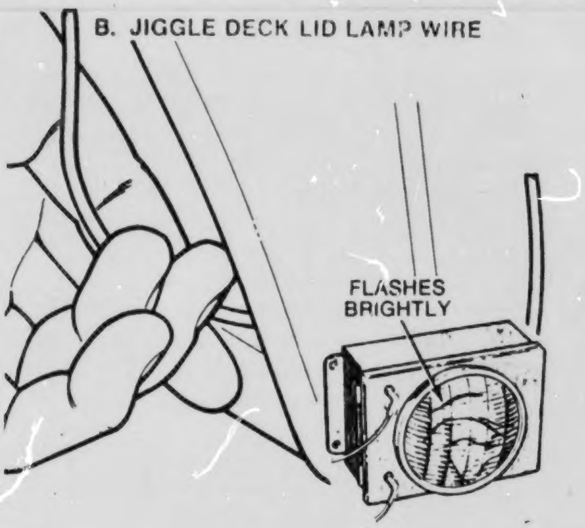
Our test procedure then is to go around the car and jiggle wires to try and make the short happen. If the bare wire touches ground, the loud test lamp will get very loud and very bright. In this, we'll observe Zimmerman's first law: start with the easiest to get at places.

Test A. Pry out the door jamb switches and jiggle the light green wire.
Results. Only a dull glow in the tester.


A. JIGGLE DOOR JAMB WIRES, ETC.

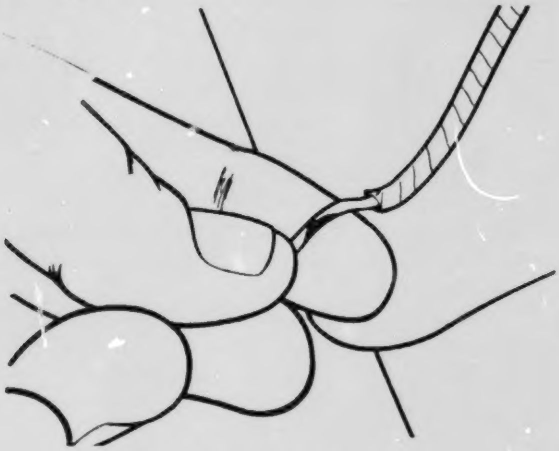
Test B. Open the trunk and jiggle the wire that leads to the trunk lamp.
Results. The tester signals a short by flashing brightly.

Conclusion. A bare spot on the wire is grounding.


B. JIGGLE DECK LID LAMP WIRE
FLASHES BRIGHTLY

Step 5. Verify the Problem

We then inspect the wire visually. A clip that secures it is not attached. The wire has chafed against a sharp edge on the deck lid hinge, and removed some of the insulation. When it touches bare metal, the fuse blows.



Step 6. Repair

We repair the wire by taping it up with insulating tape. Also, to prevent a recurrence of the problem, slip a split length of vacuum hose over the section of the wire that's near the hinge. And clip the wire up away from the hinge.

Step 7. Test the Repair

To finish the job, remove the loud tester and install a new fuse. Check that all the components on circuit 54 operate okay.

Summary- Diagnosis of Intermittent Short to Ground

To diagnose an intermittent short to ground, we first checked to find out what circuits were connected to the fuse that burned out. We then connected the tester in place of the fuse and tried to make the short happen. It didn't happen when we closed the switches one at a time, so we had to jiggle wires. Had we not discovered the short this way, our last resort would be to trace all the wires on the car and check visually for the short. Occasionally that will be required, but systematic testing first should always be the rule.

Electrical Competencies- Electrical Fundamentals

No. A - 7 How To Use A Test Light And A Continuity Tester

Worksheet # 1

Name ________________________ Date __________ Grade __________

During the course of the year, a number of vehicles will enter the shop with electrical wiring problems. Each student will, during the course of the year, locate and repair at least two of these problems using a test light and/or a continuity tester. It is highly recommended that one of these problems will be caused by a short circuit, and the other by an open circuit. In the spaces provided on the left hand side of the paper, describe the electrical problem. In the spaces provided on the right hand side of the paper, describe the test procedure used. Make sure you have your instructor initial your worksheet after you have successfully completed each of the problems.

Problem Description	Test Procedure
1.	

Date __________ Instructor's Initials __________

Problem Description	Test Procedure
2.	

Date __________ Instructor's Initials __________

Electrical Competencies- Electrical Fundamentals

No. A - 7 How To Use A Test Light And A Continuity Tester

Test #1

__Directions:__ Select the one best answer for each question.

1. When you operate a switch in an open circuit:
   a. sparks fly
   b. there are strange odors
   c. fuses blow
   d. nothing happens
   e. none of the above

2. An open circuit may be caused by:
   a. the ground is loose or disconnected
   b. a connector broken, separated, or corroded
   c. the lamp filament or other load component is burnt out
   d. a wire broken or loose from a terminal
   e. all of the above

3. When you use a jumper wire and connect it between the load and a known good ground, you are checking to see if the problem is:
   a. grounding
   b. a blown fuse
   c. a short circuit
   d. the load is not operating
   e. none of the above

4. When you use a jumper wire and connect it between the load and a known "hot" terminal, you are checking to see if the problem is:
   a. grounding
   b. a blown fuse
   c. a short circuit
   d. the load is not operating
   e. none of the above

5. When using a jumper wire, be sure your jumper wire is:
   a. 1/4 the size of the wire in the circuit
   b. at least as heavy as the wire in the circuit
   c. 1/2 the size of the wire in the circuit
   d. 1/10 the size of the wire in the circuit
   e. none of the above

6. A 12-volt test light (circuit tester) is used to check to see if the circuit is:
   a. grounded at the test point
   b. "hot" at the test point
   c. shorted at the test point
   d. open at the test point
   e. none of the above

7. A "wrap-around" test light is especially handy for testing wires:
   a. in hard-to-get-at places
   b. that cross and are connected
   c. that cross and are not connected
   d. that have intermittent opens
   e. none of the above

No. A-7 How To Use A Test Light And A Continuity Tester

8. To prevent short circuits from using a self-powered test light:
   a. Keep the probe tip sharpened
   b. always connect it by a series circuit
   c. tape up exposed holes
   d. Always connect it with a 50 ohm resistor
   e. answers a and c

9. When using the self-powered test light (continuity tester) the component to be tested must be:
   a. connected to the automative battery
   b. electrically removed from the circuit
   c. connected to a chassis ground
   d. connected to a safety device
   e. none of the above

10. A possible cause for a dim bulb is:
   a. the ground is bad
   b. the ground is open
   c. a poor connection
   d. the load component may be faulty
   e. all of the above

11. In order for a circuit to operate:
   a. there must be power to the load
   b. the load must be okay
   c. the circuit must have continuity from the load to ground
   d. answers a, b, and c
   e. anweres a and b only

12. A "short" circuit is a condition where:
   a. two wires cross
   b. a "hot" conductor is touching something it shouldn't be
   c. a conductor has become an insulator
   d. a path of more resistance is taken
   e. the ground for the load has been lost

13. A "dead" short to ground is a condition where:
   a. two hot feed wires are crossed; both would operate from the same switch
   b. a hot conductor is bare and touches ground when it is bounced or jiggled
   c. a "hot" conductor is grounded directly to the chassis or a ground wire
   d. the battery will become discharged by a constant draw
   e. answers a and c

14. An "intermittent" short to ground is a condition where:
   a. two hot feed wires are crossed; both would operate from the same switch
   b. a hot conductor is bare and touches ground when it is bounced or jiggled
   c. A "hot" conductor is grounded directly to the chassis or a ground wire
   d. the battery will become discharged by a constant draw
   e. answers a and c

15. A "cross-circuit" short is a condition where:
   a. two hot feed wires are crossed; both would operate from the same switch
   b. a hot conductor is bare and touches ground when it is bounced or jiggled
   c. a "hot" conductor is grounded directly to the chassis or a ground wire
   d. the battery will become discharged by a constant draw
   e. answers a and c

Electrical Competencies- Electrical Fundamentals

No. A-7 How To Use A Test Light And A Continuity Tester

16. Diagnosing a short to ground requires:
    a. some kind of tester between the circuit and ground
    b. a jumper wire
    c. an ammeter
    d. an chmmeter
    e. answers b and c

17. To diagnose a short to ground with the self-powered test light:
    a. use a jumper wire from the fuse to ground
    b. an ammeter must be connected in series with the fuse box
    c. an ammeter must be connected in series with the load component
    d. connect a jumper wire from power to ground
    d. Isolate the circuit from power and ground

18. If there's a short to ground in a circuit protected by a breaker you may:
    a. blow a fuse
    b. hear the breaker click on and off rhythmically
    c. over heat the breaker and cause permanent damage to the fuse box
    d. blow a fuse link
    e. none of the above

19. To diagnose a short to ground with the self-powered test light:
    a. connect the test light between the circuit and ground-light will glow if circuit is grounded.
    b. connect the test light in series with the load
    c. connect the test light across the fuse box
    d. connect a jumper wire from power to ground
    e. replace the fuse with one with 1/2 the amperage rating

20. An open circuit is"
    a. "live"
    b. one with sparks flying
    c. one with strange odors
    d. "dead"
    e. answers a, b, and c

AUTO MECHANICS

Electrical Competencies - Electrical Fundamentals

No. A-8 How To Connect Wires

OBJECTIVE:

After competing this exercise the student will be able to join wire and install terminals by using either solder or solderless methods.

EXPLANATION:

Make and solder three wire splices and one end terminal by soldering. Install a solderless terminal on a wire.

MATERIALS NEEDED:

Four pieces of 18 ga. or heavier wire, approximately six inches long.
One solderless terminal.

TOOLS NEEDED:

Soldering gun or copper, solder, flux, wire stripper, and solderless terminal crimper.

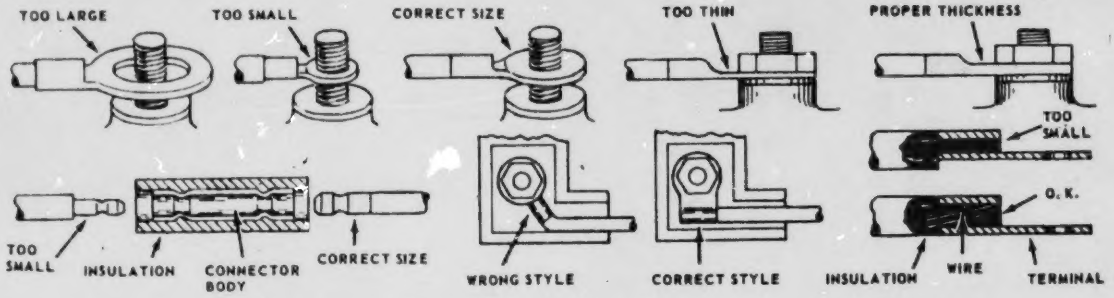
References	Do
#1. p. 6-9, 6-10	#1. Read the assigned reference.
#2. --	#2. Read the information sheet.
#3. p. 461-462	#3. Complete the worksheet assignment.
#4. --	#4. Check with the instructor.
#5. --	#5. Take written test.
#6. --	#6. Check with the instructor.
#7. --	
#8. p. 26-31 & 37-46	

Information Sheet #1

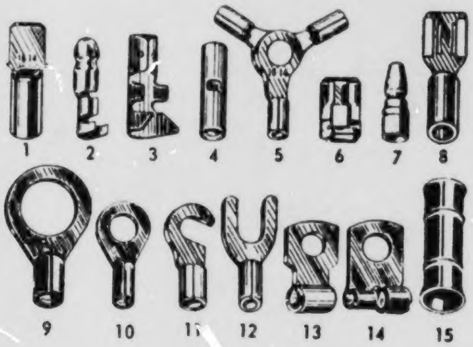
1. Selecting Proper Terminals

After the wire gauge is determined, select the proper size and type terminal. The terminal selected must be suitable for the unit connecting post or prongs. It must have sufficient current carrying capacity and should be heavy enough to prevent breakage through normal wire flexing and vibration. The picture shows some common errors in terminal selection.

Arrange terminals so they have clearance from metal parts that could ground or short them out. On critical applications or where heavy vibration is present, use a terminal such as the ring type that completely encircles the post. In the event it loosens, the wire will not fall off. NOTE: The terminal barrel size and wire size should be matched.


TOO LARGE
TOO SMALL
CORRECT SIZE
TOO THIN
PROPER THICKNESS
TOO SMALL
O. K.
TOO SMALL
INSULATION
CONNECTOR BODY
CORRECT SIZE
WRONG STYLE
CORRECT STYLE
INSULATION
WIRE
TERMINAL

Some common errors in terminal selection.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Common primary wire terminal types. 1–Male slide. 2–Bullet or snap-in. 3–Female snap-on. 4–Butt connector (must be crimped). 5–Three way connector. 6–Female slide. 7–Bullet. 8–Female slide. 9–Lug. 10–Ring. 11–Hook. 12–Spade. 13–Roll. 14–Flag. 15–Female bullet connector.

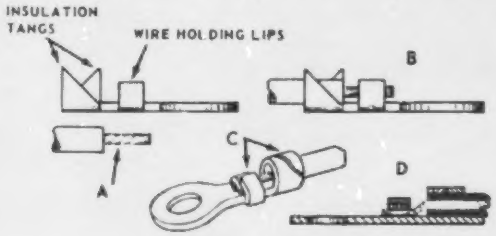
2. Attaching Terminals

Terminals may be either soldered or crimped in place. For general use, crimping is fast and forms a good connection. Soldering, if properly done, forms excellent connection, and on some important applications may be desired. It is possible to both solder and crimp a connection. Solder is used to form an electrical path and is not depended on for mechanical strength! To make a reliable crimp connection, a crimping tool must be used. Substituting a pair of pliers to crimp a wire will only weaken the terminal barrel and leave a poor connection, although it might appear to be solid.

3. Soldering Terminals

Terminals do not have to be especially made for soldering but the lip-type terminal tan lends itself to soldering better than the closed or open barrel tang.

To solder the lip type, strip the wire back as shown. Insert the wire as shown in B. Crimp the wire holding lips, one after the other, tightly over the wire then carefully fold the insulation tang around the insulated portion of the wire as in C.

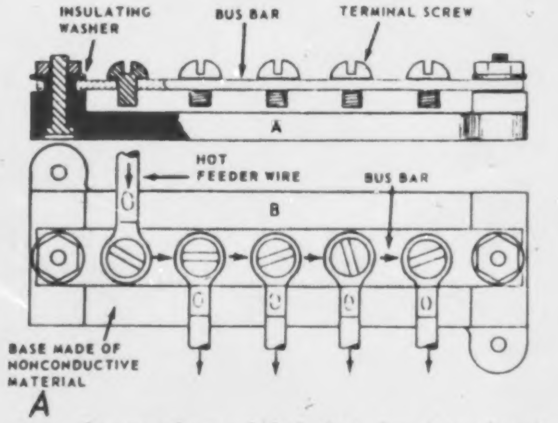

INSULATION TANGS
WIRE HOLDING LIPS
B
C
A
D

Soldering lip type terminal.

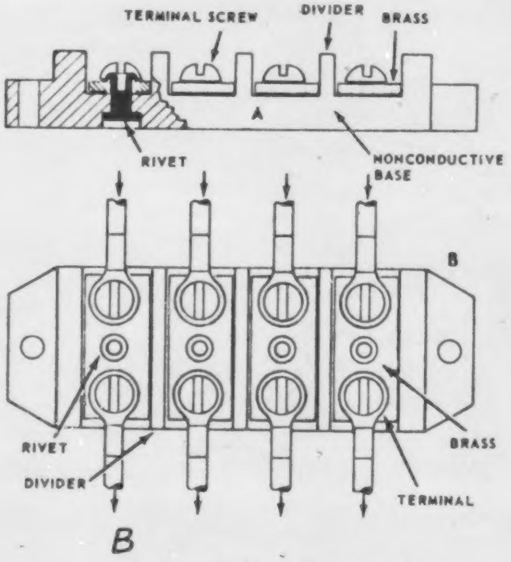
Using ROSIN CORE (NOT ACID CORE) wire solder, place a drop of solder on the holding lips. Hold the iron in contact with the drip until it flows into the lips and wire. Do not hold the iron in contact with the terminal any longer than necessary as this tends to melt the insulation.

4. Terminal Blocks

The terminal block is used to supply current to several circuits from one feeder source. The hot wire (wire connected to source of electricity) is attached to one terminal. This terminal is connected to all others by a bus bar (metal plate). See picture A below.


INSULATING WASHER
BUS BAR
TERMINAL SCREW
A
HOT FEEDER WIRE
BUS BAR
B
BASE MADE OF NONCONDUCTIVE MATERIAL
A

One type of terminal block. Notice how the one hot wire is attached to the bus bar thus supplying current to the other leads


TERMINAL SCREW
DIVIDER
BRASS
A
RIVET
NONCONDUCTIVE BASE
B
RIVET
DIVIDER
BRASS
TERMINAL
B

Junction block. (Screw type.)

5. Junction Block

The junction block serves as a common connection point for a number of wires. It may be of the terminal screw or the plug-in type. Unlike the terminal block, the junction block merely connects one wire to a corresponding wire on the other side. There is no common bus bar. See picture B on preceeding page.

6. Aluminum Wiring Repair

Early 1975 General Motors cars have either aluminum or copper wire in the main body harness. The copper wiring harness has a black plastic conduit covering and the aluminum wiring harness a brown plastic conduit covering. Complete use of aluminum wire in the main body harness was phased into the entire car production as the stock of copper harnesses was depleted.

The aluminum wire harness is made of solid 14- and 16-gauge insulated wires; wires are two sizes larger than the corresponding copper wires to maintain the same current-carrying capacity.

The aluminum harness is used in a location where it is not subject to flexing. The harness is routed in the usual manner beneath the left side of the instrument panel, down to the floor pan and along the left rocker, and then to the top of the left wheelhouse panel where it connects to the regular copper wiring harness to the rear lighting.

The aluminum harness requires special repair procedures that are outlined in the Fisher Body Manual.

7. Terminals and Splice Clips

To assure minimum resistance through a circuit, a new terminal and splice clip must be used when you repair the aluminum body harness.

The terminal and splice clip have serrations (ribs) in the crimp area to penetrate through any aluminum oxide (coating that forms on the surface of the wire) and to control overdisplacement (crushing) of the wire when the terminals or splice clips are being attached to the wire. These parts are also tin plated to reduce the possibility of galvanic corrosion occurring between the terminal and wire or splice clips and wire. To further inhibit corrosion, a corrosion preventive compound (petroleum jelly) is also applied at the terminal and/or aplice clip locations when repairs are made to the harness.

8. Battery Terminals

When selecting terminals, be certain they are physically strong enough to withstand vibration, corrosion and other elements wo which it will be exposed.

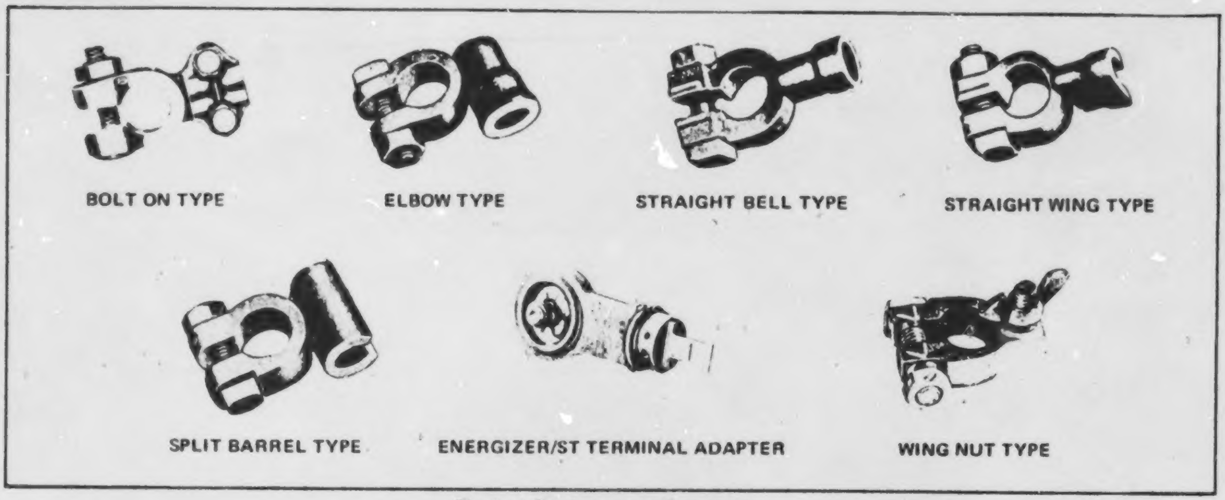
Terminals are attached to cables three different ways; soldering, crimping, and clamping. In all cases the cable insulation must be stripped from the conductor, exposing only enough conductor to fill the portion of the terminal where the connection is to be made.

A winged terminal should have the front wings bent around the cable conductor and the rear wings around the cable insulation. Solder terminal using rosin flux. Acid flux (unless thoroughly washed off) will corrode the connection. Heat should be applied to the terminal until the solder melts and flows freely. Avoid using too much heat or leaving the heat applied after the solder has flowed.

Do not cool the solder joint by immersing in water, allow to cool at room temperature. Improper soldering will result in high resistance connections which will result in voltage drops in the electrical circuit.

Solderless terminals must be crimped or clamped so as to tightly mate with the core. The crimp must not weaken the terminal or cable so that vibration will cause breakage.

The wiring on late model vehicles makes use of many types of "push on" or "snap type" terminals. These terminals should be attached using crimping tool and/ or solder.



Typical Replacement Terminals

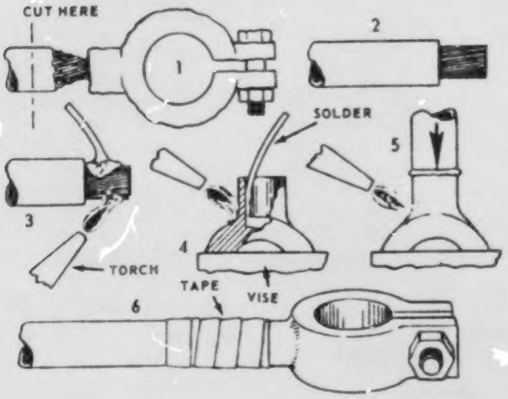
9. Soldering Battery Terminals

The common practice is to replace the entire battery cable when the terminals are no longer fit for use. However, if it becomes necessary to install a new terminal, use the following procedure.

Cut the cable back far enough to remove the corroded section. Peel the insulation (ground cables often have none) back equal to the depth of the terminal barrel. Place the terminal in a vise, open barrel end up.

Using an acetylene torch (low heat, flame high in acetylene) heat the stripped cable end. Using rosin core wire solder, flow solder freely into the wire until all strands have been tinned. It may help to rub on a little rosin type soldering paste to assist with tinning.

Place a dab of soldering paste in the terminal barrel. Heat with the torch (keep flame on outside of terminal). When hot, flow solder into the barrel until about one-quarter full. While retaining the heat with the torch, force the tinned cable down into the socket. When it slips in the full depth, solder will flow up and over the lip of the barrel. Hold the heat, moving the flame around the terminal outside, for a few seconds longer to allow the heavy cable to heat up and bond firmly to the barrel. Remove heat and hold cable steady until solder sets. Cool under a cold tap. Dry terminal and cable insulation and then apply plastic tape as shown in the picture on the following page.



Soldering a battery terminal. 1-Cut off corroded section. 2-Strip. 3-Tin. 4-Tin barrel and add solder. 5-Insert cable. 6-Tape.

For open barrel terminals, tin both cable and inside of barrel heavily. While heating, slide together as above. Do not try to solder battery terminals with a soldering iron- it will not produce sufficient heat.

10. Attaching Spark Plug Wire Terminals

The picture shows various spark plug wire terminals. The boots shown protect against moisture and dirt than can cause flashover (spark jumping to ground along the outside of the plug porcelain top). Ready-made sets often bond the boots to both the terminal and wire for added protection against flashover.

When selectingplug end terminals, choose a shape that will snap on the plug without bending the wire sharply. The same applies to distributor terminals, see picture.

Although some plug end terminals have a sharp barb that is designed to penetrate the insulation and contact the wire (as well as providing holding power). it is good practice to strip the insulation enough to allow the wire to be bent around and laid against the outside of the insulation. This insures a good electrical contact. See A in picture. Some distributor end terminals, such as that in B. have the barbs both at the sides and end. Wire stripping is not necessary if the barb is carefully inserted into the wire end. When attaching terminals to resistance type plug wires, always use staples. The staple is pushed up into the wire, thus insuring a large contact area with the special conductor, see C in the picture.

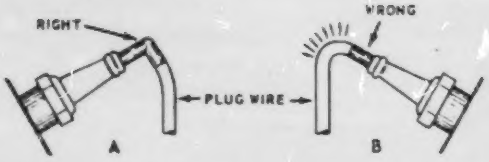
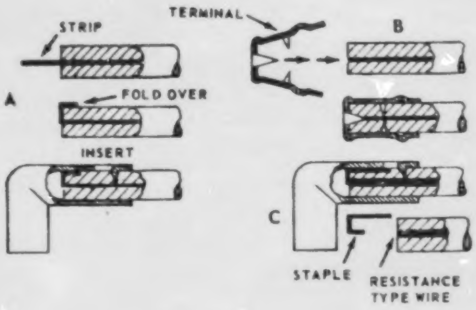
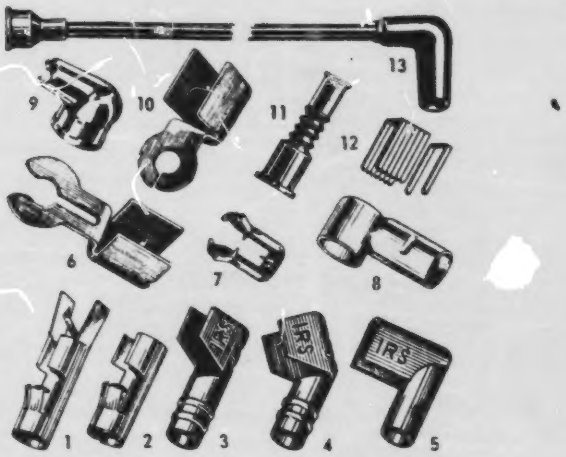


Fig. 6-20. Choose a terminal shape that will allow the wire to be attached without sharp bending. The wire in B will soon fail.



Attaching secondary wire terminals. A-Attaching a plug end terminal to a regular (non-resistance) spark plug wire. B-Attaching a distributor end terminal. C-Using a staple when attaching a terminal to resistance type wire.



Spark plug wire terminals and boots. 1, 2, 7-distributor end terminals. 3, 4, 5, 6, 8, 10-spark plug end terminals. 9-Right angle distributor end boot. 11-Flexible plug end boot. 12-staples for use with resistance type wire. 13-Replacement plug wire with boots bonded to wire.

SUMMARY

Primary wire (copper stranding, relatively thin insulation) is used for circuits handling battery voltage. Secondary wire (stainless steel, carbon impregnated thread and elastomer stranding with very heavy insulation) is used on the ignition high tension circuit. Plastic is widely used for insulation.

All automotive wire uses a stranded (not solid) wire conductor.

The AWG (American Wire Gauge) is determined by the cross sectional area in circular mils. The larger the AWG number, the smaller the size. A micrometer or wire gauge can be used to determine wire size.

Spade, lug, flag, roll, slide, ring and bullet terminal types are used.

Terminal blocks allow one feeder wire to service a number of other wires. These can be of the screw, bullet or slide type.

Junction blocks provide a central connecting point for a number of wires.

Fuse blocks give protection against circuit overloads.

A wiring harness ocntains a number of wires either taped together or pulled through loom. This keeps common wires neatly arranged and facilitates installation.

Automotive electrical systems are color coded. Use an accurate wiring diagram for troubleshooting or replacing wires.

Line voltage, wire length and electrical load must be taken into consideration when choosing wire gauge. A wire gauge chart will assist in making the right selection. Remember that undersize wires increase resistance, reduce unit efficiency and can overheat and burn. On two-wire circuits (one wire for ground) count the length of both wires. A 6v. system requires heavier gauge wire than the 12v. system.

Be certain that terminals are of the correct style and size. They may be soldered or crimped to the wire. Battery replacement terminals should be soldered. When crimping, use a suitable crimping tool. If soldering, use rosin core wire solder. Always slide insulation boots, housing, etc., on the wire before attaching terminal.

Use staples when installing terminals on resistance type sencondary leads. Handle secondary resistance wire carefully.

Wire ends may be joined by soldering, using butt connectors or by attaching bullet or slide connectors.

When installing wires, keep away from heat, oily areas and moving parts. Terminals must be clean and tight. Use clips to prevent chafing and excessive vibration.

When adding accessories, fuse the circuit as close to the source as possible. Do not tap into the headlight circuit for an accessory.

Clean, tight connections with proper size wire and good insulation, are imperative. When troubleshooting, always check connections and insulation. Replace cracked, spongy or frayed wires.

Many wiring checks can be made with a simple test light.

Printed circuits find some application on the auto.

1. Repairing Hard-Shell Connectors

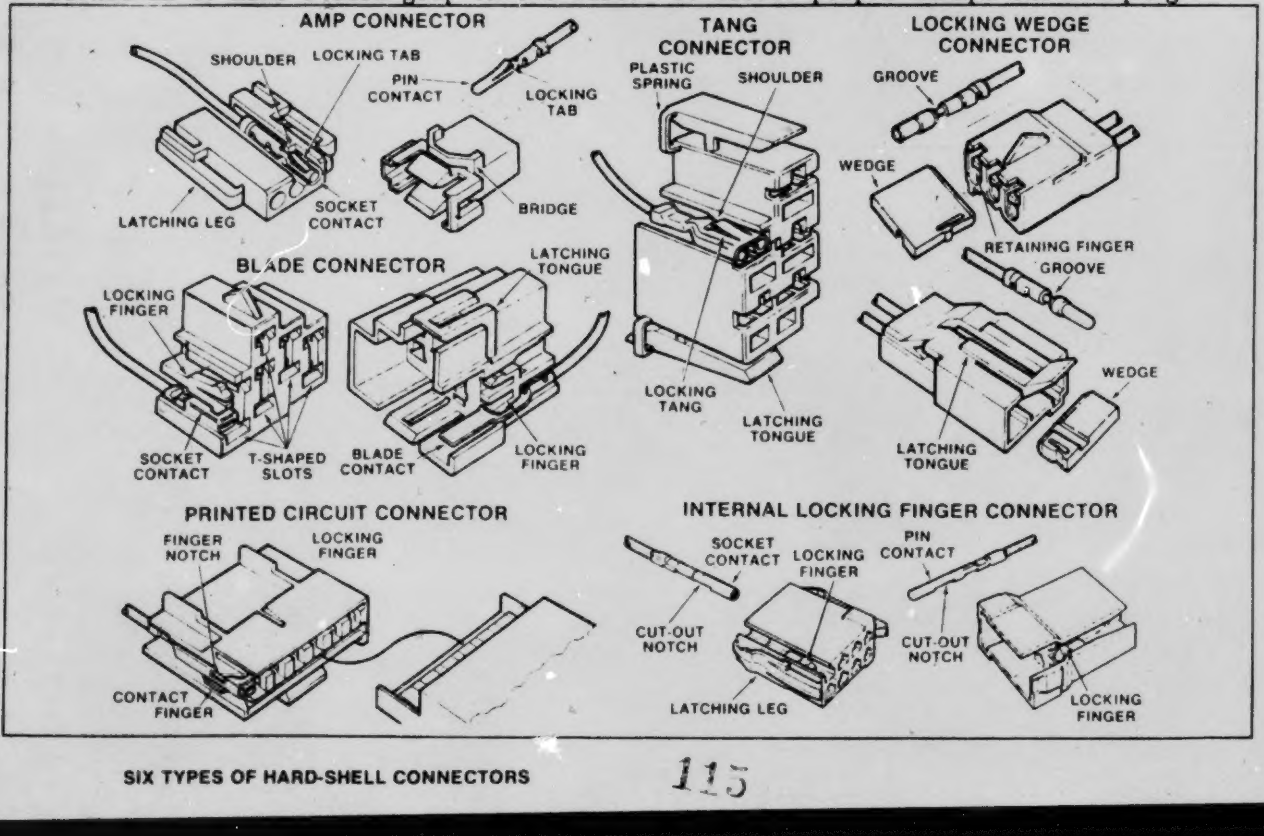
Unlike molded connectors, the terminal contacts in most hard-shell connectors can be replaced. Hard-shell connectors that are weatherproof (like solid-state ignition module connectors) and certain other hard-shell connectors in which the leads are molded into the shell, have nonreplaceable terminals. The picture shows six major types of hard-shell connectors in which the terminals can be replaced. Whenever the connector shell shows evidence of burning, melting, or breaks or cracks, replace the connector shell. Replace individual terminals that are burnt, corroded, distorted, or loose.

To replace a connector terminal;

1. Remove the terminal from the connector shell.
2. Cut the wire as close as possible to the terminal.
3. Strip the wire, using the correct tool. (Insulation should project beyond the insulation crimp tabs, but should not touch the wire crimp tabs. The wire should project into the terminal approximately 1/16-inch beyond the wire crimp tabs.)

NOTE:
The insulation crimp must be tight to prevent the insulation from sliding back on the wire when the wire is pulled. The insulation must be visibly compressed under the crimp tabs. The ends of the crimp tabs must be turned in for a firm grip on the insulation.

The wire crimp must be with all wire strands inside the crimp. The terminal must be fully compressed on the wire strands. The ends of the crimp tabs must be turned in to make a firm grip on the wire. To assure proper crimps the crimping


AMP CONNECTOR
SHOULDER
LOCKING TAB
PIN CONTACT
LOCKING TAB
LATCHING LEG
SOCKET CONTACT
BRIDGE
TANG CONNECTOR
PLASTIC SPRING
SHOULDER
LOCKING TANG
LATCHING TONGUE
LOCKING WEDGE CONNECTOR
GROOVE
WEDGE
RETAINING FINGER
GROOVE
WEDGE
LATCHING TONGUE
BLADE CONNECTOR
LOCKING FINGER
LATCHING TONGUE
SOCKET CONTACT
T-SHAPED SLOTS
BLADE CONTACT
LOCKING FINGER
PRINTED CIRCUIT CONNECTOR
FINGER NOTCH
LOCKING FINGER
CONTACT FINGER
INTERNAL LOCKING FINGER CONNECTOR
SOCKET CONTACT
LOCKING FINGER
PIN CONTACT
CUT-OUT NOTCH
LATCHING LEG
CUT-OUT NOTCH
LOCKING FINGER

SIX TYPES OF HARD-SHELL CONNECTORS

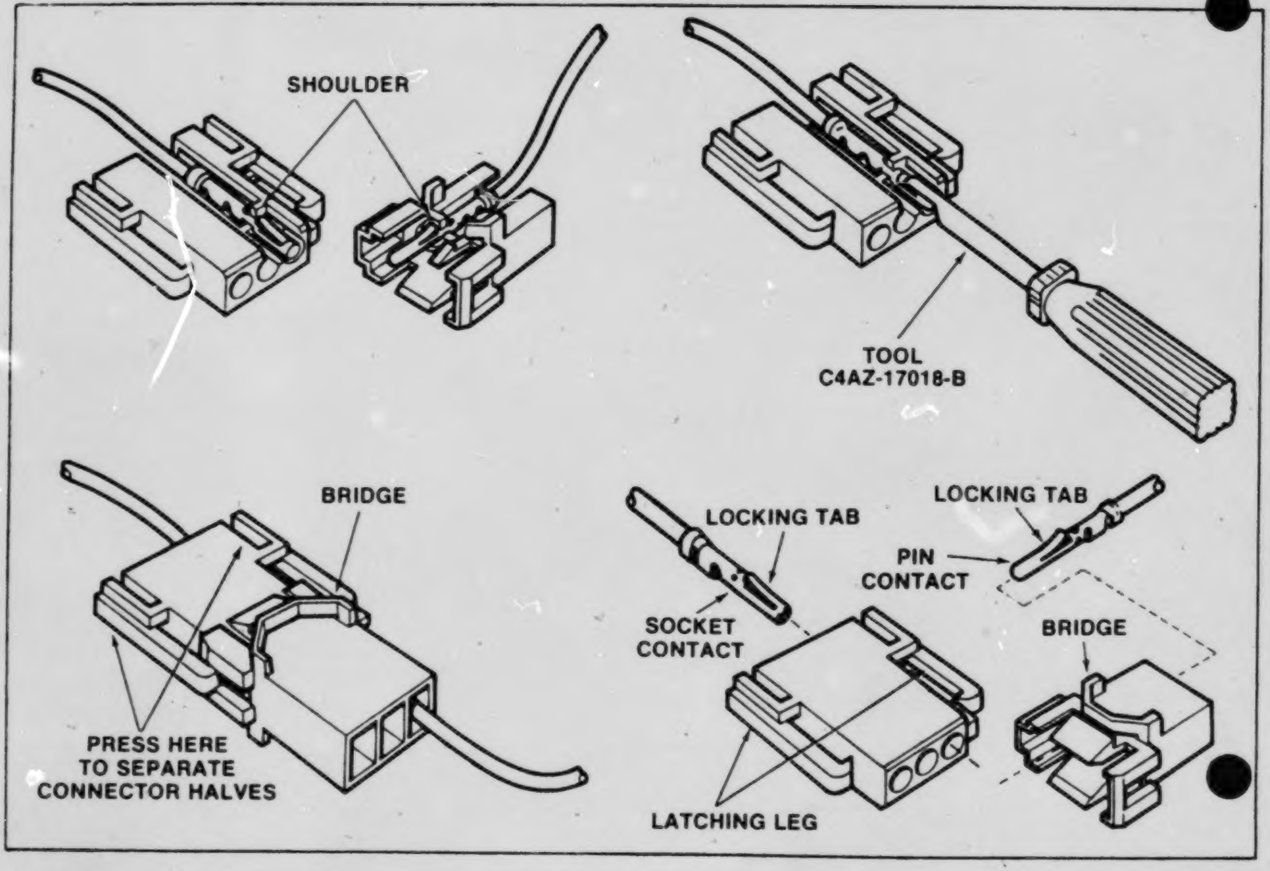
tool must have anvil-shaped crimping jaws to turn in the ends of the crimp tabs, as well as different size jaws to accommodate different size wires.

To test the crimp, attempt to pull the wires out of the terminal. Use an ohmmeter across the wire and terminal to check for a good crimp. There should be no measurable resistance between the wire and terminal.

2. Repairing Amp-Type Connectors

Amp-type connectors can be identified by a "bridge" or the pin half and "latching legs" on the socket half. The pins and sockets are held in the shell by locking tabs. To replace a pin or socket:

1. Squeeze the tabs, as shown in the picture, to separate the connector.
2. Insert special tool CAAZ-17018-B into the mating end of the shell, over the pin or socket to be replaced.
3. Push in on the wire to free the locking tab.
4. Push in and rotate the tool to force the locking tab to retract into the pin or socket.
5. Pull on the wire to pull the pin or socket from the shell.
6. Using standard techniques, crimp on the proper size and type new pin or socket.
7. Push the pin or socket into the shell until the retaining tab snaps out behind the shoulder in the shell.


SHOULDER
TOOL
C4AZ-17018-B
BRIDGE
PRESS HERE
TO SEPARATE
CONNECTOR HALVES
LOCKING TAB
LOCKING TAB
PIN
CONTACT
SOCKET
CONTACT
BRIDGE
LATCHING LEG

REPAIRING AMP-TYPE CONNECTORS

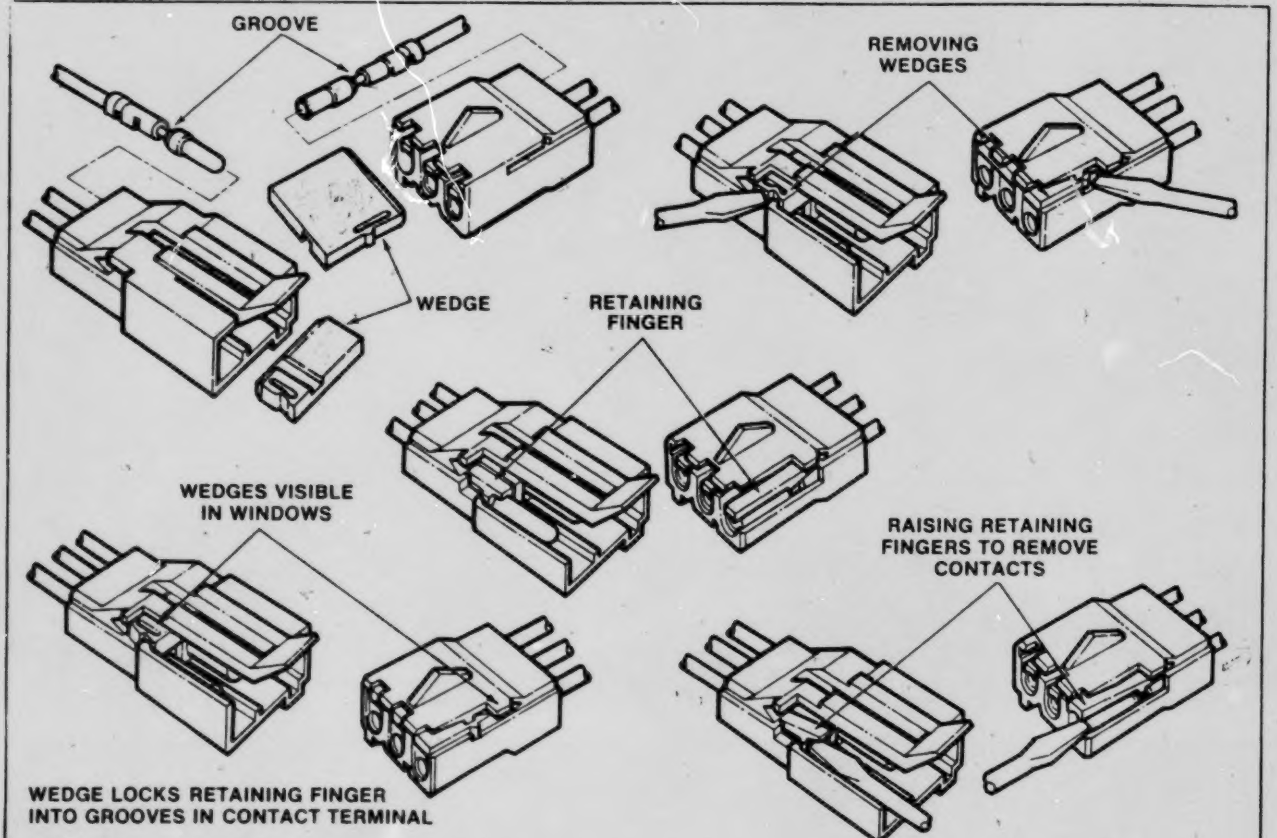
3. Repairing Locking-Wedge Connectors

Locking-wedge connectors can be identified by red or brown colored wedge release tabs which are visible through windows in the connector shell. The pins and sockets are held in the shell by plastic retaining fingers which are part of the shell and which snap between two shoulders on the pins and sockets.

The wedges are held in the shell by a snap-lock tab on one end of each wedge which snaps into the window in the shell when the wedge is fully sealed. To replace a terminal in a locking-wedge connector:

1. Lift the latch tongue and pull the connector halves apart.
2. Press the wedge locking tab in and up (toward the mating end of the shell) until the wedge is forced out of the cavity in the shell.
3. Use a 1/8-inch wide screwdriver blade to lift the retaining finger away from the pin or socket.
4. Pull on the wire to withdraw the terminal pin or socket.
5. Replace the pin or socket with the proper size and type new pin or socket, according to standard techniques.
6. Insert the pin or socket into the shell.
7. Push on the wire until the retaining finger snaps into place in the pin or socket.

NOTE: Wedges are not included in replacement shells. When ordering new shells, also order the proper size wedge separately, under basic part number 14A468.


GROOVE
REMOVING WEDGES
WEDGE
RETAINING FINGER
WEDGES VISIBLE IN WINDOWS
RAISING RETAINING FINGERS TO REMOVE CONTACTS
WEDGE LOCKS RETAINING FINGER INTO GROOVES IN CONTACT TERMINAL

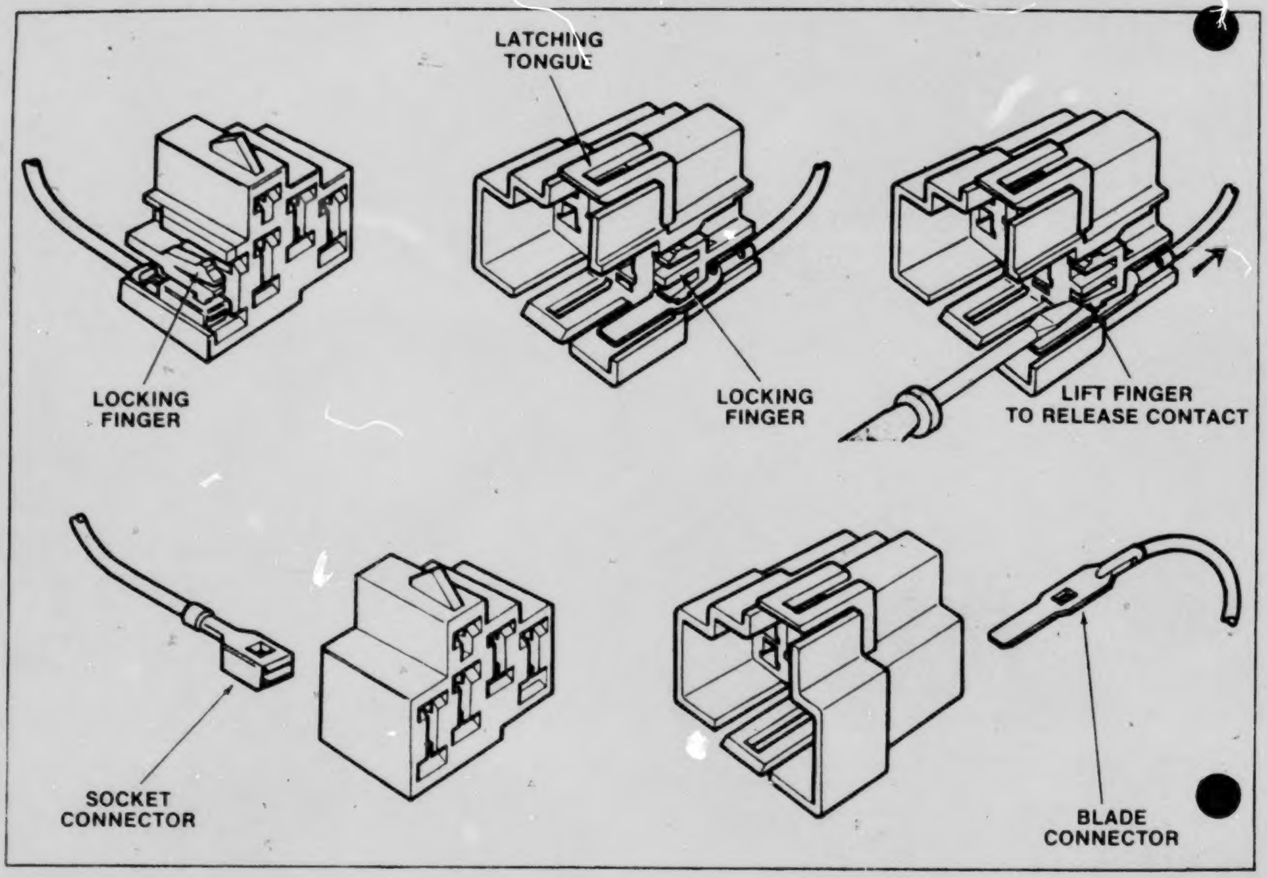
REPAIRING LOCKING-WEDGE CONNECTORS

4. Repairing Ford Blade Connectors

Ford blade connectors are identified by the T-shaped (or joined T-shaped,1-shaped) cavities in the mating end of the socket half of the shell, and by the visible blade terminals in the male half of the shell. The blades and sockets are held in the shell by plastic locking fingers, which are part of the shell, and which snap into rectangular cutouts in the blades and sockets.

The sockets are designed to make firm contact against both sides fo the blades. To replace a blade or socket:

1. Lift the latch tongue and pull the connector halves apart. (The spring-loaded feature of the sockets against the blades make the connectors characteristically difficult to pull apart.)
2. Use a 1/8-inch wide screwdriver blade to lift the locking finger away from the blade or socket. (The locking nib on the locking finger is deeper than on wedge connectors. The finger must be forced well back to free the blade or socket.)
3. Pull on the wire to withdraw the blace or socket.
4. Replace the blace or socket with the proper size and type new blade or socket, according to standard techniques.
5. Insert the blade or socket into the shell.
6. Push on the wire until the blade or socket snaps into place.



REPAIRING FORD BLADE CONNECTORS

NOTE: It is important, when joining the connector halves, to make sure the two halves are pushed firmly together. The blades and sockets make very firm contact when engaged; strong pressure is required to join, as well as separate them After joining the connector halves, always inspect the connector to make sure that the latching tonque is all the way over its mating nib.

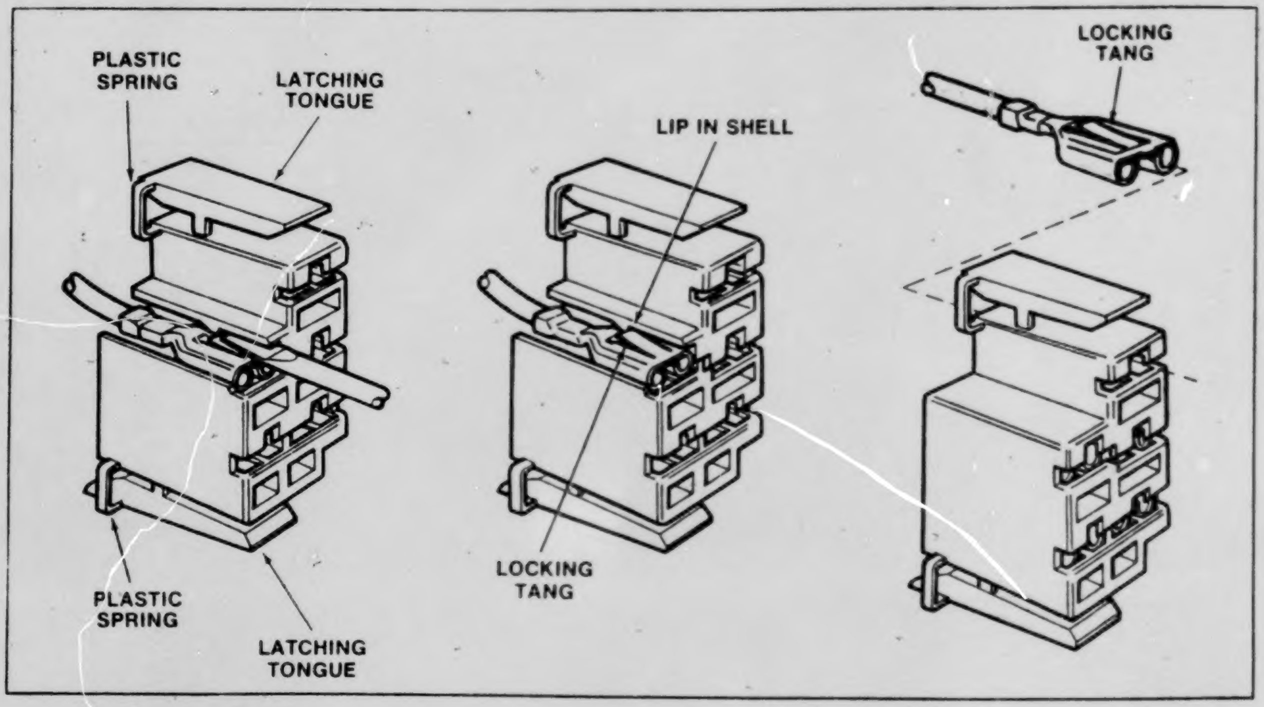
Note also that the socket half of blade connectors is sometimes used to connect to components which have blade-type contacts.

5. Repairing Tang-type Connection

Tang-type connectors are primarily used to connect the harness to the ignition switch. They are identified by the unique shape of their latching tongues which have plastic springs.

Sockets are held in the shell by tangs on the socket which snap out behind lips in the shell. To repair a tang-type connector:

1. Squeeze the locking tongues at the spring end and pull the connector off.
2. Insert a 1/8-inch screwdriver blade (or a heavy paper clip) into the narrow slot beside the socket.
3. Push on the wire (toward the mating end of the connector) and press in on the screwdriver (or paper clip) to force the tang down even with the socket.
4. Pull on the wire withdraw the socket.
5. Replace the socket with the proper size and type of new socket, according to standard techniques.
6. Align the tang on the socket with the narrow slot on the shell.
7. Push in on the socket until the tang snaps into place behind the lip in the shell.

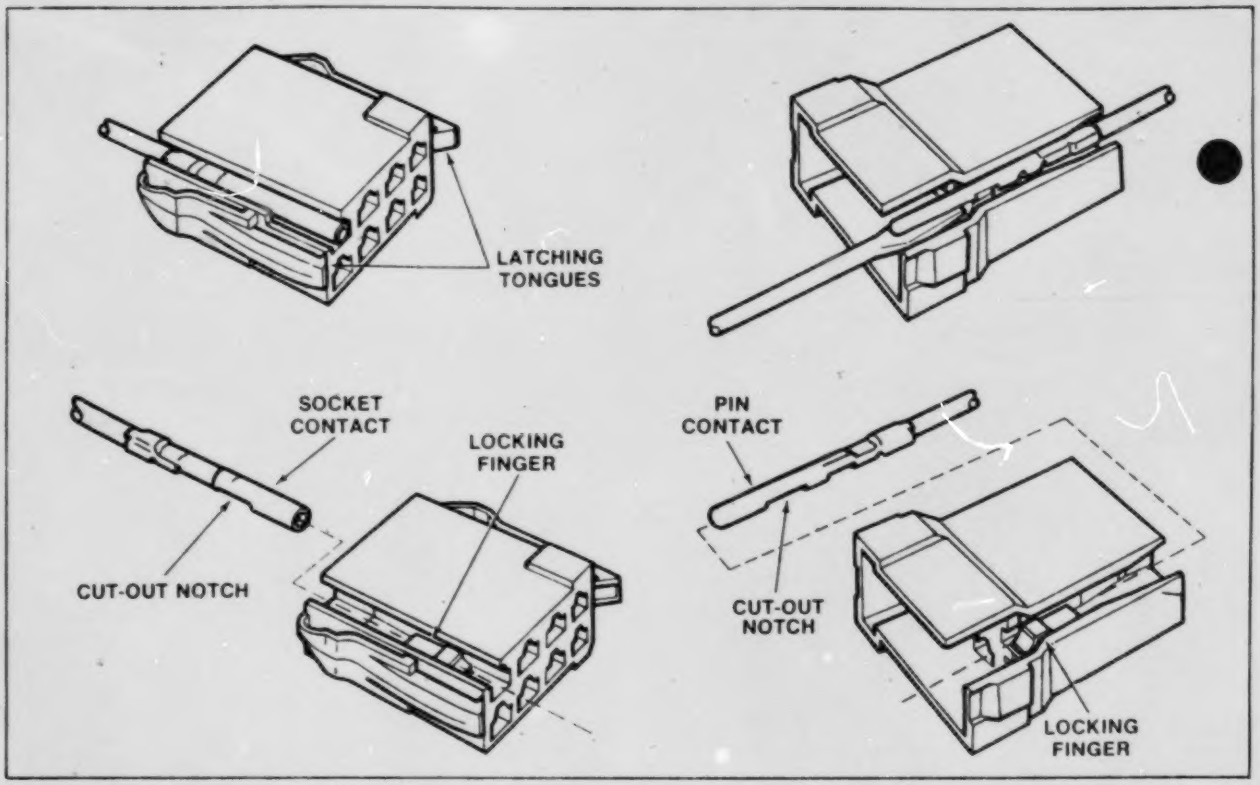


REPAIRING TANG-TYPE CONNECTORS

6. Repairing Internal-Locking-Finger Connectors

Internal-locking-finger connectors are identified by the fingers which are clearly visible in the contact cavities in the mating ends of the shell. The plastic fingers, molded into the shell, engage cutout notches in the pins and sockets to hold them in the shell. To repair an internal-locking connector.

1. Lift the latching tongues and pull the connector halves apart.
2. Insert a 1/8-inch screwdriver blade into the mating end of the pin or socket cavity.
3. With the screwdriver blade, lift the plastic finger away from the pin or socket.
4. Pull on the wire to withdraw the pin or socket from the shell.
5. Replace the pin or socket with the proper size and type new pin or socket, according to standard techniques.
6. Align the notch in the pin or socket with the plastic finger in the cavity of the shell.
7. Push the pin or socket in until the finger engages in the notch.

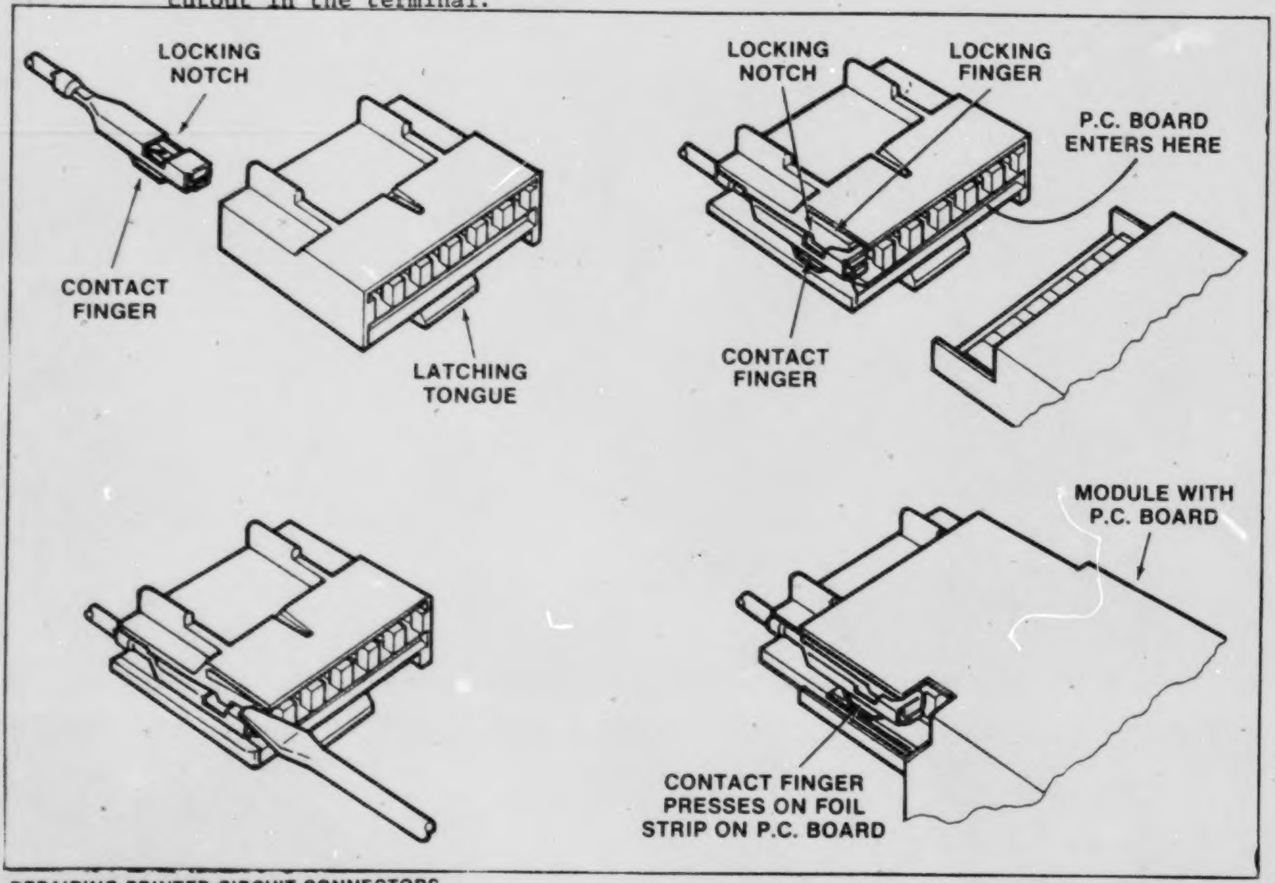


REPAIRING INTERNAL-LOCKING-FINGER CONNECTORS

7. Repairing Printed Circuit Connectors

Printed-circuit connectors are identified by the rounded ends of the terminals that are visible at the mating end of the shell. Contact fingers on the terminals protrude through partitions in the shell into the cavity which receives the printed circuit board. The connector contacts have spring-loaded fingers which press against copper strips on the printed circuit board when the board is inserted into the cavity in the shell. The connector contact terminals are held in the shell by plastic locking fingers, which are part of the shell, and which snap into rectangular cutouts in the contact terminals. To repair a printed-circuit connector:

1. Lift the latching tongue and pull on the wires to separate the connector from the component.
2. Using a 1/8-inch screwdriver blade, lift the locking finger away from the contact erminal. (The locking fingers are on the side of the contact opposite the printed circuit board.)
3. Pull on the wire to withdraw the contact terminal from the shell.
4. Replace the terminal with the proper size and type new terminal, according to standard techniques.
5. Align the new terminal so that the contact finger on the terminal faces the printed circuit board cavity in the shell.
6. Insert the terminal into the channel in the shell.
7. Push the terminal in until the retaining finger snaps into place in the cutout in the terminal.


LOCKING NOTCH
CONTACT FINGER
LATCHING TONGUE
LOCKING NOTCH
LOCKING FINGER
P.C. BOARD ENTERS HERE
CONTACT FINGER
MODULE WITH P.C. BOARD
CONTACT FINGER PRESSES ON FOIL STRIP ON P.C. BOARD

REPAIRING PRINTED-CIRCUIT CONNECTORS

Electrical Competencies- Electrical Fundamentals

No. A - 8A How To Connect Wires

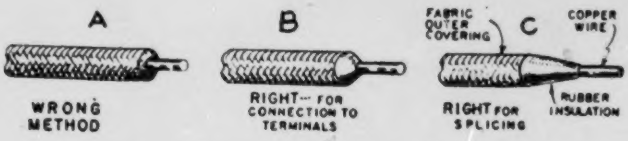
Worksheet # 1

Name ________________________________ Date ____________ Grade ____________

1. Removing Insulation:

Before a wire can be connected to a switch or other device, or spliced to another wire, the insulation must be removed. There is a right way and a wrong way to do this. Do not cut it off sharply, as shown in A, as there is too much danger of nicking the copper wire, leading to breaks later. If the wire is to be connected to a terminal hold your knife at an angle as shown in B. If the wire is to be spliced to another wire, hold the knife as in sharpening a pencil, as shown in C in the same picture.

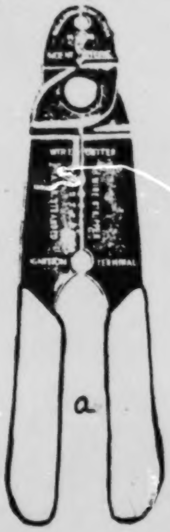
Whether the wire is to be connected to a terminal or is to be later soldered, you absolutely must remove all traces of insulation from the copper conductor. Some kinds of wire have a tinned copper conductor which makes it easy to strip the insulation off cleanly. Other kinds sometimes require condiderable scraping to clean the conductor. Always be sure that the conductor is absolutely clean.



Wrong and right methods of removing insulation from wires.

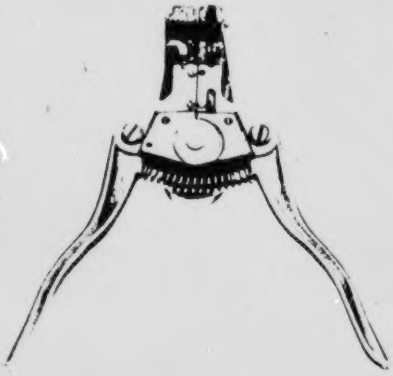
2. Wire Shippers

One of the most convenient and time saving tools available for wiring jobs is a wire stripper. (Picture B & C). It removes the desired length of insulation without damage to the copper conductor. The tool in picture A attaches solderless terminals by indenting the terminal into the copper strands and compressing the wings to grip the insulation. It can also be used to cut and strip cable and to close the wings of other types of terminals including spark plug terminals. Other types of terminals can be attached with the tool by bending the terminal wings around the copper strands and indenting the terminal into the copper strands.



a

Wire stripper.



b

Wire stripper head.

c

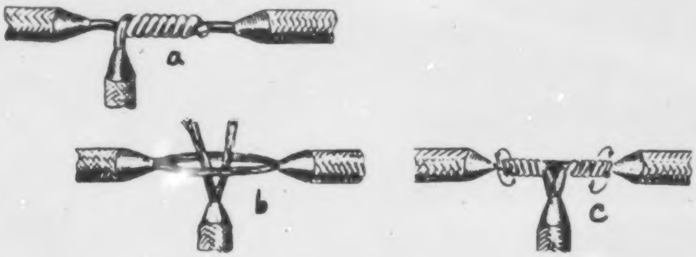
Wire stripping.

Electrical Competencies- Electrical Fundamentals

No. A - 8A How To Connect Wires

Worksheet # 1
Page 2

3. Make a tap splice: Strip approximately one inch in the center of one wire. Strip approximately 3/4 inch off one end of the other wire. Divide the center stripped portion strands in approximately half. (See pictures) Pass the end of the other wire through the divided strands. Divide the passed through wire into two sets of strands. Wrap each group of strands around the tapped wire. (See picture C)

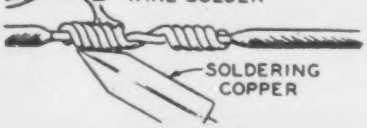


Picture (a) shows an acceptable tap splice. Picture (b) and (c) show a much superior splice, with considerable mechanical strength which can be made with very little more effort.

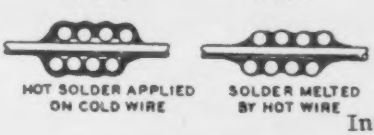
Instructor's Initials ____________

4. Soldering: The first requirement of good soldering is that both the wire and the soldering copper must be absolutely clean. Use a non-acid flux; rosin is suitable for the purpose and rosin-core solder in wire form is handy.
CAUTION: Do not use a Sal Ammoniac block to tin your iron. Sal Ammonica leaves deposits in the tinning on your copper which will cause your splices to corrode. This corrosion will also occur using acid core solder or acid flux.
In soldering, apply the soldering copper to the joint, untilthe wire itself is hot enough to melt the solder when it is touched to the wire, as shown. Having a bit of solder on the soldering copper as it is held against the wire, forms a liquid contact between the soldering copper and the wire, leading to a more rapid heating of the wire than if the bare copper were used. If the soldering copper is at the right heat, the wire will quickly heat sufficiently for good soldering; if the soldering copper is not hot enough, the wire will heat slowly because the heat will flow from the splice into the wire under the insulation, leading to a poor joint and possibly damaged insulation.

If the soldering operation is properly done, solder will flow down into every little open space in the splice, making a good electrical joint. See the picture for difference between poor and good soldering. Solder the splice you made in part 3 above.



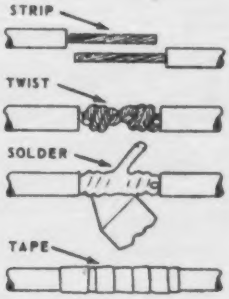
In soldering, do not drop hot solder on cold wire. Heat the wire until it is hot enough to melt solder.



Hot solder applied to cold wire will lie on the surface. Solder melted by hot wire fills all spaces, makes a good joint.

Instructor's Initials ____________

5. Make a Wire Splice: Take the two ends of your tapped splice wire and strip approximately 1" off each end. Twist the wires as shown in the picture. When splicing stranded wire in this way, don't twist the strands after stripping. Leave them as loose strands. You can twist your splice into a much tighter splice this way. Complete the splice and have the instructor check it.



Instructor's Initials __________

After soldering, insulation must be added to the joint, equal in insulating value to that which was on the wire originally.
The easiest method is to use plastic tape that has been developed specially for electrical work. It has high insulating value even in a relatively thin layer, thus making for compact joints. If you wrap several layers of this tape tightly on top of each other, around a pencil. Then cut through them with a sharp knife and you will find that they have fused into a single layer.

In applying this tape, start at the tapered end of the insulation on the wire, wrap spirally toward the other end, and then back to the beginning; continue back and forth until you have a layer of insulation as thick as the original insulation. Keep the tape stretched at all times.

Instructor's Initials __________

7. Making a "thin" splice: On occasion a situation will be encountered which requires a very "thin" splice, one which is very little larger than the insulated wire itself. To make this type of splice take your two remaining wires and strip about 1" off of each. "Flare" or "brissel" out the wires. Intermesh the two brisseled out ends as shown in (a) of the following picture. Twist the strands as shown in (b) and solder as shown in (c). Show the completed splice to the instructor.

(Picture on next page)

Instructor's Initials __________

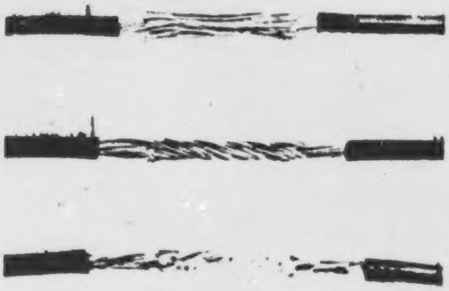
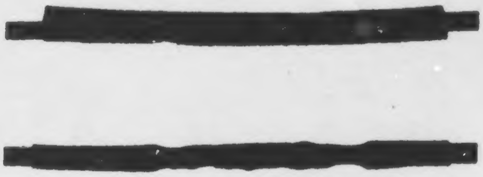


Fig. 2.33. Wiring splicing.

8. Using heat shrink sleeving: To complete our "thin" splice in step 7 we must now insulate the wire with as little increase in diameter as possible. To do this we will use a product called heat shrink tubing (sleeving). Heat tubing comes in a number of sizes to handle different size wires. Choose a diameter which is just large enough to slide easily over the insulation on the wire to be spliced. Cut a piece about 1" to 1 1/2" longer than the splice to be covered. Shove the sleeving over the insulation on one side of the splice before joining the wires. CAUTION: Be sure the sleeving is far enough up the wire so the heat of soldering the splice will not reach it and cause it to begin shrinking. If this happens , the sleeving may "freeze" to the insulation making it impossible to slide it down over the splice after it is completed. Complete your splice and solder the wire. After the wire has cooled, slide the insulation down over the splice. Heat the tubing by passing a hot soldering copper under it. The heat will cause the tubing to shrink tightly around the wire and overlapped insulation causing a tight, firm, electrically sound, and permanent seal.

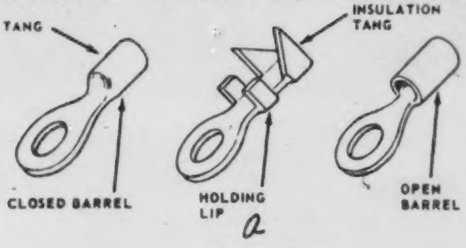
Insulate your "thin" splice with heat shrink sleeving. You may slide your sleeving on over one end of your spliced wire to make up for not having installed the sleeving before completing the splice. CAUTION: Remember, many good splices have had to be taken spart because the mechanic doing the work forgot to put the sleeving on before completing the splice. Heat the sleeving with your soldering copper by passing it under the sleeving (CAUTION: Don't touch the sleeving with your soldering copper when heating it. If you do it will melt and stick to the tip of your copper.) After putting the sleeving on your splice, show it to your instructor.



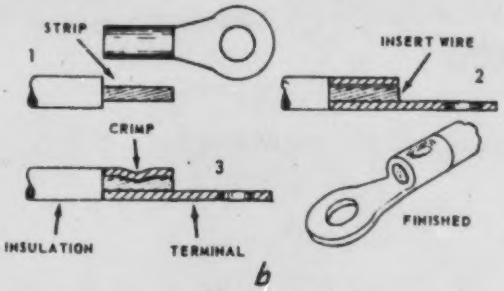
Insulating wire splice with heat shrink tubing.

Instructor's Initials __________

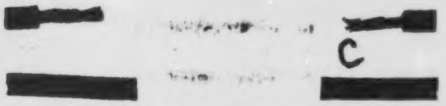
9. Crimp-on Terminals and Splices: To eliminate the need for soldering a number of crimp-on splices and terminals are available. In the picture below (a) are 3 types of crimp-on terminals. Picture (b) shows installing an open barrel crimp-on terminal. Picture (c) shows a crimp-on butt connector or splice.


TANG
INSULATION TANG
CLOSED BARREL
HOLDING LIP
OPEN BARREL
a

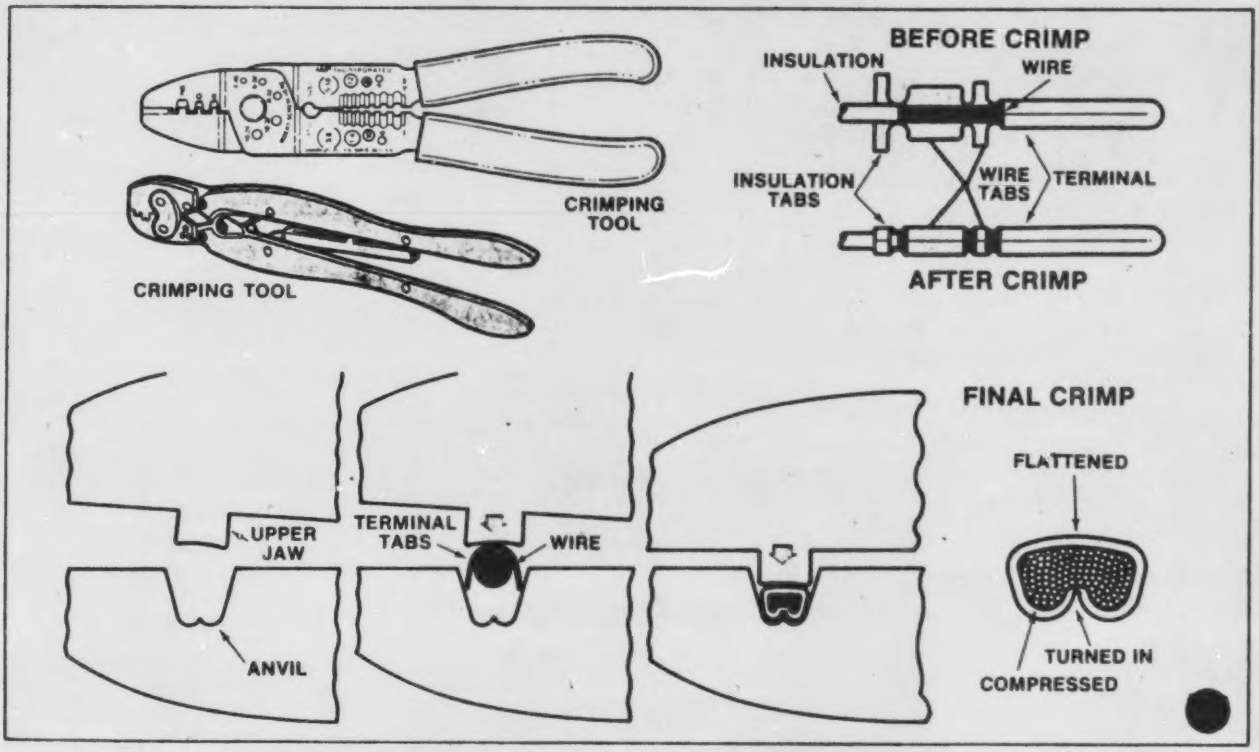
Terminal tangs.


STRIP
1
INSERT WIRE
2
CRIMP
3
INSULATION
TERMINAL
FINISHED
b

Crimping a terminal.



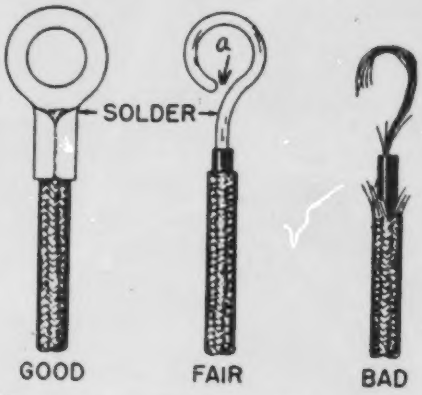
Obtain a crimp-on terminal from your instructor. Strip an end of one of the wires from your "thin" splice to the appropriate length and install the crimp on terminal. The picture below shows a crimping tool similar to the one you will use. The picture al shows another type of crimp termianl and how it is installed.


BEFORE CRIMP
INSULATION
WIRE
INSULATION TABS
WIRE TABS
TERMINAL
AFTER CRIMP
CRIMPING TOOL
CRIMPING TOOL
FINAL CRIMP
FLATTENED
UPPER JAW
TERMINAL TABS
WIRE
ANVIL
TURNED IN
COMPRESSED

Show your completed crimp-on terminal to your instructor.

Instructor's Initials ________

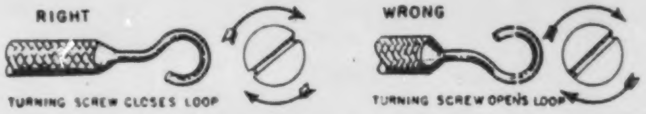
10. If a crimp-on or solder on terminal is not available an acceptable substitute can be made by twisting the stranded wire tightly after stripping and tinning it. This produces a solid conductor which then can be bent into a loop as shown in the picture.



A soldered-on lug, or solidly soldered (dipped) strands must be used to form a good connection

A superior lug can be constructed by closing the loop at point (a) and again tinning the wire. This will produce a loop nearly as good as a terminal.

Remember when connecting a wire under a screw terminal the loop should go around the screw in a clockwise direction. See the picture below.



Always insert the loop on a wire so that tightening the screw closes the loop.

Take the remaining end of your "thin" splice, the end of the tap wire from your tap splice, strip them, tin them, and form them into a loop as shown in the preceeding pictures. Make theloop fit a number 10 screw and the other a 1/4" screw. Close the loop at point (a) as shown in the picture and re-tin it to form a complete ring. Show these two loops to your instructor

Instructor's Initials ________

Electrical Competencies- Electrical Fundamentals

No. A - 8 How To Connect Wires

Test # 1

Name ______________________________ Date ________________ Grade ____________

Directions: Select the one best answer for each of the following questions.

1. When stripping insulation from the end of a wire to place a terminal on it, the distance the insulation should be removed is:

a. 1/2 the length of the terminal barrel
b. 3/4 the length of the terminal barrel
c. equal to the length of the terminal barrel
d. 1 1/2 times the length of the terminal barrel
e. 2 times the length of the terminal barrel

2. The correct type of solder to be used when making a connection by soldering is:

a. rosin core
b. acid core
c. hollow core
d. plain core
e. all of the above

3. When soldering a connection, the solder should not be depended on for:

a. forming an electrical path
b. preventing corrosion
c. sealing watertight
d. mechanical strength
e. all of the above

4. When wires will probably be separated at some future time, the type of connector(s) used is:

a. closed barrel
b. open barrel
c. slide
d. bullet
e. answers c and d

5. Primary wire is used for circuits handling:

a. high tension voltage
b. battery voltage
c. secondary circuit voltage
d. up to 12,000 volts
e. none of the above

6. Junction blocks provide:

a. one feeder wire to service a number of other wires
b. a place for color coding
c. protection against circuit overloads
d. central connecting point for a number of wires
e. an indication of wire cross sectional area

7. Terminal blocks provide:

a. one feeder wire to service a number of other wires
b. a place for color coding
c. protection against circuit overloads
d. central connecting point for a number of wires
e. an indication of wire cross sectional area

8. All automotive type wire is of the:

a. hollow type
b. stranded type
c. solid type
d. rolled type
e. all of the above

9. Comparing the terminal barrel size to the wire size, the barrel size should be:

a. 2 gauges smaller than the wire size
b. the same size as the wire size
c. 2 gauges larger than the wire size
d. 4 gauges larger than the wire size
e. answers a and c

10. Wire size an be determined by using a:

a. micrometer or wire gauge
b. micrometer or bullet gauge
c. wire gauge or bullet gauge
d. dial indicator or wire gauge
e. dial indicator, micrometer, or wire gauge

11. The first step in the process of soldering is to:

a. apply flux
b. heat the joint
c. melt solder into the joint
d. clean the surfaces to be soldered
e. tin the soldering copper

12. The type of connectors that may be used in an automobile are:

a. spade
b. lug
c. flag
d. role
e. all of the above

13. Battery terminal are attached to cables by:

a. soldering
b. crimping
c. clamping
d. all of the above
e. answers b and c

14. When a wire passes through sheet metal it should be protected by:

a. fiberglass insulation
b. grommets
c. plastic laminations
d. a plastic film
e. none of the above

15. When removing the insulation from the end of a wire, it should be removed:

a. at a right angle to the wire
b. tapered, as if sharpening a pencil
c. frayed and rough
d. with a single edge razor blade
e. answers a or b

16. Wire size for an automobile is denoted by:

a. color coding
b. bulb size
c. harness number
d. gauge number
e. answers a and d

17. When a splice is completed on an aluminum wire, it should be protected by first applying:

a. grease
b. petroleum jelly
c. tape
d. flux
e. heat shrink tubing

18. Substituting a pair of pliers for a crimping tool is:

a. acceptable
b. recommended
c. not recommended
d. okay for solderless connectors
e. okay for solder connectors

19. A wire too small for a circuit will result in:

a. voltage loss
b. an increase in amperage
c. a decrease in resistance
d. an increase in voltage
e. answers b and d

20. Comparing the wire size needed for a six volt system to a twelve volt system, the six volt system would require:

a. a smaller cross-sectional area wire
b. a single strand wire
c. dual wiring
d. a larger gauge number wire (ex. 22 gauge)
e. a larger cross sectional area wire

21. Deteriorating of wire insulation may be caused by:

a. old age
b. heat
c. chemical exposure
d. all of the above
e. none of the above

22. After repairing a terminal on a hard shell connector, you should test across the wire and terminal with:

a. an ohmmeter
b. an ammeter
c. a voltmeter
d. a test light
e. all of the above

23. Locking-wedge connectors can be identified by:

a. blue or pink colored wedge release tabs
b. orange or black colored wedge release tabs
c. red or brown colored wedge release tabs
d. a bridge or pin half
e. latching legs

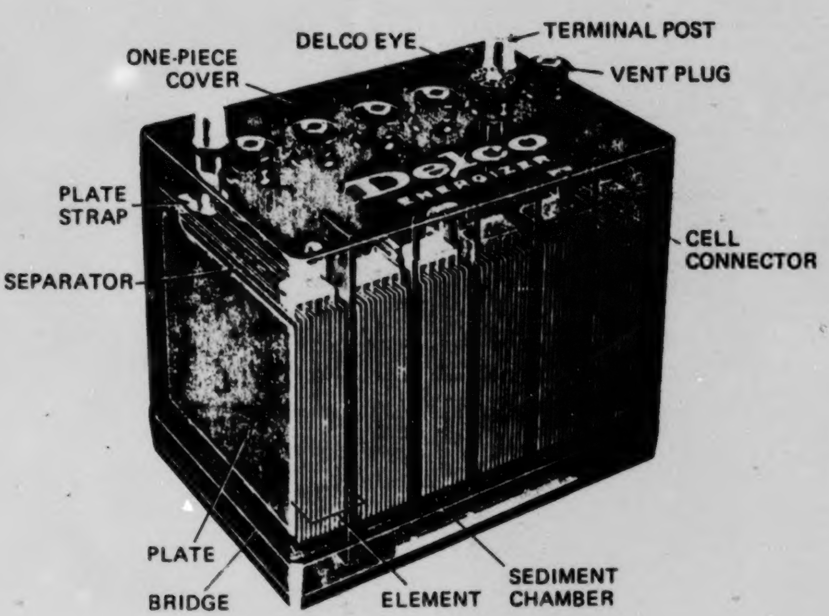
24. Printed circuit connectors can be identified by:

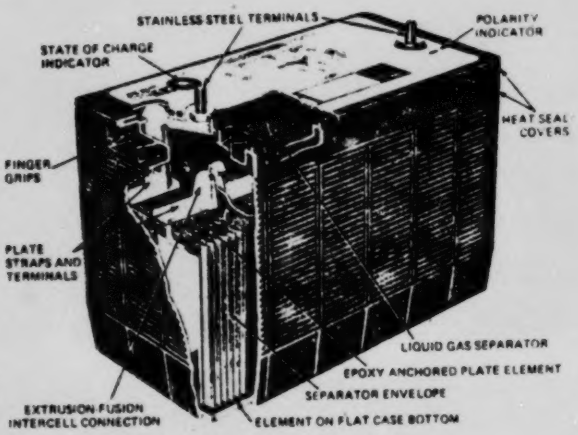
a. latching legs
b. rounded ends of the terminals at the mating end of the shell
c. a bridge or pin half
d. red or brown colored wedge release tabs
e. none of the above

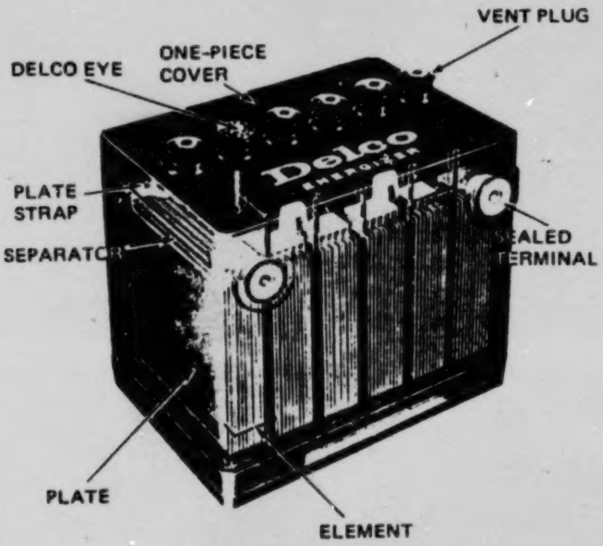
25. Repairing amp-type connectors requires:

a. no special tools
b. a small screwdriver
c. replacement of the wedges
d. a special tool
e. the use of acid core solder

AUTOMOTIVE BATTERIES


DELCO EYE
TERMINAL POST
ONE-PIECE COVER
VENT PLUG
PLATE STRAP
CELL CONNECTOR
SEPARATOR
PLATE
BRIDGE
ELEMENT
SEDIMENT CHAMBER
Delco ENERGIZER


STAINLESS STEEL TERMINALS
POLARITY INDICATOR
STATE OF CHARGE INDICATOR
HEAT SEAL COVERS
FINGER GRIPS
PLATE STRAPS AND TERMINALS
LIQUID GAS SEPARATOR
EPOXY ANCHORED PLATE ELEMENT
SEPARATOR ENVELOPE
EXTRUSION-FUSION INTERCELL CONNECTION
ELEMENT ON FLAT CASE BOTTOM


VENT PLUG
DELCO EYE
ONE-PIECE COVER
PLATE STRAP
SEPARATO
SEALED TERMINAL
PLATE
ELEMENT
Delco ENERGIZER

REFERENCE

The texts chosen were selected because they are in current use by the instructors who compiled this manual. You should have a copy of at least one in your shop.

The text books are to be used as references for each exercise in this book. For each exercise you will find a number followed by page numbers. Look up the book number on this list and the page numbers will corresponds to the exercise you are working. For example if you find 5. 103-211 in the reference section you would check this reference list and find that book No. 5 is Auto Mechanics by H. E. Ellinger. In that book, pages 103-211 will apply to the exercise you are working.

	TEXT	AUTHOR	PUBLISHER
1.	Auto Service and Repair 1975	Stockel	Goodheart - Willcox
2.	Auto Mechanics Fundamentals 1974	Stockel	Goodheart - Willcox
3.	Motor Auto Engines and Electrical Systems 1975	Hearst Corporation	Motor
4.	Automotive Encyclopedia 1975	Tobotdt - Johnson	Goodheart - Willcox
5.	Auto Mechanics Second Edition	Ellinger	Prentice - Hall
6.	Automotive Mechanics	Crouse	McGraw - Hill
7.	The Auto Book	Crouse	McGraw - Hill
8.	Automotive Chassis And Accessory Circuits	Brezcha/Samuels	Prentice - Hall

Auto Mechanic's
Batteries
No. B - Index

B -1 -- Safety

B -2 -- Visual Inspection

B -3 -- Battery Maintenance And Service

B -4 -- Specific Gravity Test

B -5 -- Battery Capacity Test (High Rate-Discharge)

B -6 -- 3 Minute Charge Test

B -7 -- Individual Cell Voltage Test

B -8 -- Battery Drain Test

B -9 -- Battery Charging

SCHOOL ______________________ STUDENT ______________________
INSTRUCTOR ______________________ YEAR GRAD ______________________

AUTOMOTIVE ELECTRICAL COMPETENCIES -BATTERIES

	COMPETENCY	JR	M	C	SR	M	C	VOC	M	C	IND	M	C
B-1	Safety												
B-2	Visual Inspection												
B-3	Battery Maintenance and Service												
B-4	Specific Gravity Test												
B-5	Battery Capacity Test (High Rate-Discharge)												
B-6	3 Minute Charge Test												
B-7	Individual Cell Voltage Test												
B-8	Battery Drain Test												
B-9	Battery Charging												
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11													
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16													
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18													
19													
20													
21													

THIS COMPETENCY SHEET LISTS ALL THE SKILLS REQUIRED FOR THIS BOOK. THEY ARE LISTED IN A LOGICAL ORDER ALTHOUGH THERE IS NO FIXED SEQUENCE FOR COMPLETING THE EXERCISES. EACH HEADING HAS A COLUMN TO ITS RIGHT WITH SPACES TO ALLOW GRADING AFTER YOU COMPLETE THAT EXERCISE. WE HAVE TAKEN INTO ACCOUNT THAT NOT EVERY EXERCISE WILL BE COMPLETED THE FIRST YEAR. THEREFORE, WE HAVE SPOTS FOR JUNIOR, SENIOR, VOCATIONAL AND INDUSTRY. AS YOU COMPLETE A PARTICULAR COMPETENCY, (OR TASK) YOU WILL BE GRADED ACCORDING TO THE SCALE AT THE BOTTOM OF THIS SHEET. ALSO, IF THERE ARE ANY MATH OR COMMUNICATION SKILLS REQUIRED THEY CAN ALSO BE GRADED USING THE CODE N, 1, 2, OR 3. THE DATE OF COMPLETION WILL BE ENTERED UNDER THE APPROPRIATE YEAR AND COMPETENCY. YOU WILL HAVE THE OPPORTUNITY TO UPGRADE ANY ONE OF THESE SKILLS AT ANY TIME AFTER YOU FIRST COMPLETE THE TASK AND HAVE THE NEW RATING ENTERED ON THIS SHEET.

RATING SCALE

N = No opportunity to perform
1 = Completed exercise with close supervision
2 = Completed exercise with little supervision
3 = Completed exercise without supervision

M = Math
C = Communications

SCHOOL ____________________ STUDENT ____________________

INSTRUCTOR ____________________ YEAR GRAD ____________________

AUTOMOTIVE ELECTRICAL COMPETENCIES -BATTERIES

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21													

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Auto Mechanics
Battery Maintenance and Service

No. B- Introduction

The battery is the heart of the automotive electric system. Under certain conditions- for example, when the engine is not running- the battery supplies all the electric energy required to start the engine or operate the lights, radio, or any of the other accessories.

When the engine is running, the generator (alternator) takes over the job of supplying the electric current for the entire system. Under these conditions, the battery is the recipient. The battery also stabilizes the electric system. It is not commonly known that the generator (alternator) will not function properly without the stabilizing effect of the battery. The battery senses the condition of the electric system, then signals the brain of the system, the regulator. This in turn signals the generator (alternator) to supply the correct amount of current to compensate for any electric load placed on the system and to provide an adequate charge for the battery- a fast charging rate when the battery is low and a slower charging rate when the battery is charged up.

The system voltage under all conditions of operation depends upon the condition of the battery. The battery reacts upon the electric system differently for every condition of charge. For instance, when the battery is fully charged it offers more resistance to the efforts of the generator (alternator) to charge it, and the reverse is true when the battery is discharged. If the battery is worn out, the resulting system voltage is usually lower than normal. If the battery is sulfated, the opposite is true. A battery with a dead cell plays havoc with the vehicle's electric system in many ways. Starting will be a problem, and the generator or alternator system will be thrown out of balance. The ignition operating voltage will be reduced, causing it to function inadequately.

We cannot overemphasize the importance of the battery to the electric system. It should be obvious that the diagnostician must determine the condition of the battery as the simplest prerequisite to solving any electrical problem. Therfore, battery tests by and large will precede all electrical diagnoses.

Auto Mechanics

Electrical Competencies - BATTERIES

No. B-1 SAFETY

OBJECTIVE: After completing this exercise you will be able to understand and practice safe work habits while working on or near automotive batteries.

EXPLANATION: Severe burns and/or explosion can result from unsafe handling of batteries. To ensure your knowledge of safe work habits a 100% grade on a written safety test along with demostrated safe work practices in shop will be required.

MATERIALS NEEDED: Safety glasses

TOOLS NEEDED:

References	Do
#1.Ch. 22-1	1. Read assigned references
#2.Ch. 19,p.376	2. Study Safety information sheet
#3. ——	3. Take safety test
#4. ——	4. Check test with instructor
#5. p. 158	5. Sign and date test sheet
#6. Ch.27, p. 254	6. Give test to instructor
#7. p. 227 & 230	
#8. p. 79	

Electrical Competencies- Batteries

No. B-1 Battery Safety

Information Sheet #1

A battery should be treated with respect by the car owner and car serviceman alike. The sulfuric acid of the battery electrolyte can damage the car's paint or corrode metal parts if spilled. The acid can also cause severe burns if it contacts the skin. Wear safety glasses to protect your eyes.

If electrolyte contacts the skin, flood the area with water, then cover it with moistened baking soda. If electrolyte contacts the eyes, wash them first with water, then with a one-percent solution of baking soda. Do not rub them. Call a physician immediately.

When a battery is charging or discharging, it gives off hydrogen gas, which is highly explosive. In fact, some hydrogen gas is present above the electrolyte level in the cells at all times. Follow these safety precautions to avoid a battery explosion:

Keep sparks, open flame, and cigarettes away from batteries at all times.

Operate charging equipment in a well-ventilated area.

Do not short across battery terminals.

Do not connect or disconnect charger leads to battery terminals while the charger is turned on.

The possibility of electrical burns caused by arcing between a battery terminal and a ring or wristwatch is another hazard that is sometimes overlooked. To avoid this possibility, remove rings and watches before servicing a battery.

Batteries are heavy and can be awkward to handle. If a battery is dropped, electrolyte may be spilled or the case may be damaged. Always use a battery carrier or lifting strap to make battery handling easier and safer.

The electrolyte in a fully charged battery will not freeze until temperatures drop to 60 or 90 degrees below zero. The electrolyte in a partially charged or discharged battery,however, can freeze at temperatures of 5 degrees above zero and warmer. Winter temperatures in many areas are cold enough to freeze a weak battery.

Before charging or boost-starting a dead battery in winter, check the electrolyte in the cells for signs of freezing. If ice can be seen, or if the electrolyte level cannot be seen, allow the battery to thaw at room temperature before performing any service. Passing current through a frozen battery can cause it to rupture or explode.

The positive post of the battery, which is usually marked with a POS, or +, is somewhat larger than the negative post. Its top is sometimes painted red. The negative post is the smaller of the two, and is often painted green. It is marked with a NEG, or -. When removing battery terminals, ground cable should be removed first and replaced last.

To prevent arcing at the terminals and possible explosion. It is also important to use the correct procedure when jump starting cars to prevent arcing near the battery (NOTE PROCEDURE ON PAGE 2).

Procedure For Using Jumper Cables

1. Attach RED cable first to the POSITIVE terminal of the DEAD battery, then to the POSITIVE terminal of the booster battery.

2. Attach the BLACK cable first to the NEGATIVE terminal of the LIVE battery and then to an unpainted bolt on the ENGINE BLOCK or motor of the car with DEAD battery.

Procedure For Removing Jumper Cables

1. Disconnect cables from the ENGINE BLOCK, then from the NEGATIVE BOOSTER, FROM POSITIVE BOOSTER, and from POSITIVE DEAD BATTERY.

Electrical Competencies- Batteries

No. B-1 Battery Safety

Test

Name ______________________________ Date __________ Grade __________

T. F. 1. Danger is present when a battery is being charged due to the fact that nitrogen gas is given off.

T. F. 2. Battery electrolyte is a corrosive acid.

T. F. 3. Sulfuric acid from batteries can cause serious burns to the skin and eyes.

T. F. 4. When battery acid gets on your skin the area should be flushed thoroughly with water.

T. F. 5. Safety glasses are not required when working on or near batteries.

6. Because of the possibility of electrical burns caused by arcing between a battery terminal and a ______ ____ or ____________ they should be removed before servicing a battery.

7. Always use a __________carrier or lifting ____________to make battery handling easier and safer.

8. Electrolyte in a partially charged or discharged battery can freeze at temperatures of _____________and colder.

9. Before charging or boost-starting a dead battery in winter check the electrolyte in the cells for signs of ____________________.

10. Passing current through a frozen battery can cause it to __________ or ____ _____________.

11. Always disconnect the _____________ cable first when servicing the batter.

12. Always connect the ____________cable last when servicing the battery.

CHOOSE MOST CORRECT ANSWER

13. Batteries should be carried with:
    A. Two pair of pliers.
    B. A proper battery strap or carrier.
    C. Two box end wrenches.
    D. All of the above.

14. An open flame or spark near a battery man cause the battery to:
    A. Explode
    B. Discharge
    C. Under charge
    D. Over charge

15. Never charge a battery that is/has:
    A. Discharged
    B. Sulfated
    C. Frozen
    D. Side Terminals

16. If battery acid gets into your eyes:
    - A. Flush with H_2O and call a physician
    - B. Flush with baking soda
    - C. Rub water and baking soda into eyes
    - D. Drink a lot of water

17. The positive battery terminal (post) may be identified by:
    - A. Being marked +
    - B. Larger in size
    - C. Being painted red
    - D. Being marked POS
    - E. Answers A and C
    - F. All of the above

18. The negative battery terminal (post) may be identified by:
    - A. Being marked -
    - B. Smaller in size
    - C. Being painted green
    - D. Being marked minus
    - E. Answers A,B,C
    - F. All of the above

19. When carging a battery:
    - A. A well ventilated area is a must
    - B. Keep all sparks or flame away from area
    - C. Hydrogen gas and oxygen are given off
    - D. Do not disturb connections while charging
    - E. Do all of the above

20. When jump starting an engine, the last connection should be:
    - A. At positive terminal of the good battery
    - B. At the positive of dead battery
    - C. Ground at engine block
    - D. None of the above

21. When jump starting a car, the jumper cables should be connected:
    - A. Negative of good battery to + of a dead battery
    - B. + of dead battery to negative of dead battery
    - C. + of dead battery to engine block
    - D. + of dead battery to + of good battery and negative of good battery to engine block of car with dead battery

AUTO MECHANICS

Electrical Competencies- Batteries

No. B-2 Visual Inspection

OBJECTIVE:

After completing this exercise you will be able to perform visual inspections on an automotive battery.

EXPLANATION:

Visual inspections is the first step in battery servicing and testing and is use to determine general condition of battery, clamps, cables, and hold down/trays/boxes.

MATERIALS NEEDED:

Battery

TOOLS NEEDED:

References	Do
#1. Ch. 22 p. 1	#1. Read assigned references.
#2.	#2. Study information sheets
#3. p. 686	#3. Inspect- Complete worksheet #1 A. Electrolyte level B. Condition of battery case C. Condition of battery hold downs D. Condition of battery cables and cable ends E. Condition of battery posts F. Condition of battery caps G. Dirt on top of battery H. Battery caps I. Inspect battery trays J. Inspect battery heat shields
#4.	
#5. p. 155-156	
#6. p. 254	
#7. Ch.19, p. 224-225	
#8. Ch.3,p. 72-74,84	

Electrical Competencies - Batteries

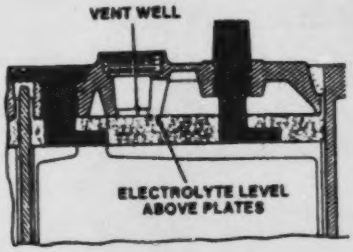
No.B 2 Visual Inspections

Information Sheet # 1

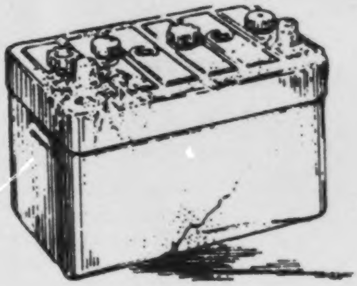
Battery Inspection

Battery service begins with inspecting and cleaning the battery and the cables. Complete battery inspection should include the following points:

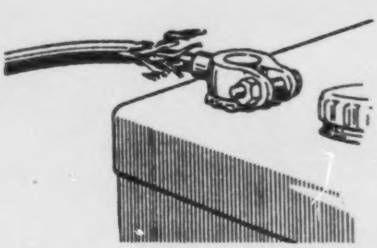
1. Check the battery electrolyte level. It should be above the tops of the plates of at the indicated level within the cells. Add water to bring the electrolyte to the correct level. Distilled water or a good grade of mineral-free drinking water may be used. Do not overfill.



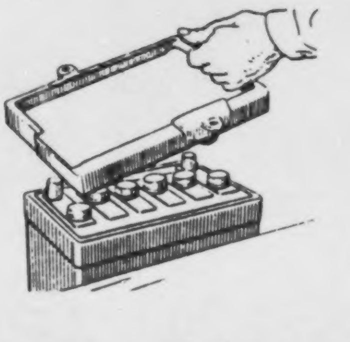
2. Inspect the battery case and cover for dirt or grease that could cause a voltage leak to ground.
3. Inspect the battery terminals, cable connectors, and metal parts of the holddown and tray for acid corrosion.
4. Inspect the battery for cracks, loose terminal posts, and other physical damage. A battery with this kind of damage is a candidate for replacement.



5. Check for missing or damaged cell caps. Replace any that are defective or missing.
6. Inspect the cables for broken wire strands, worn insulation, and loose or damaged connectors. Replace defective cables.



7. Check all cable connections for looseness and dirt.
8. Inspect the tray and holddown for looseness, damage, or missing parts.
9. Ensure that heat shields are properly installed on batteries requiring them.



Battery Selection and Rating Methods

If car owners would think of the battery as they do the fuel tank- a reservoir to be kept filled- more attention would be given to its selection and care. The battery must provide good cranking capability and adequate reserver power. Test standards and rating methods, developed by the Battery Council International (BCI) and the Society of Automotive Engineers (SAE) are designed to test a battery's ability to meet these two requirements.

When replacing a battery, check a BCI application chart to select the correct battery for the car. Pay particular attention to requirements for an optional heavy-duty battery for a car with air conditioning or several major electrical accessories. To ensure adequate cranking power and to meet all other electrical needs, a replacement battery may have a higher rating, but never a lower rating, than the original battery.

The most common battery rating methods are explained in the following paragraphs.

Cranking Performance at 0°F (Cold-Cranking Rating)

The cold-cranking rating indicates the power a battery can supply for engine cranking under adverse temperature conditions. The ampere figures (at 0°F) for this rating may be listed, for example, as 305, 315, 380, or 440. These figures represent the current flow a battery can deliver for 30 seconds at 0°F, while maintaining a voltage of 1.2 volts per cell or higher (total terminal voltage of 7.2 volts or more for a 12-volt battery). A 12 volt system generally requires one ampere for each cubic inch of engine displacement. In other words, a 350 cu. in. engine requires a battery with a Cold Cranking rating of at least 350 amps.

Reserve Capacity

The reserve capacity rating indicates the power available from a battery for ignition, lighting, and other accessories required in emergencies. The reserve capacity is listed in minutes, such as: 68, 81, 101, or 105. It is a measurement of the length of time a fully charged battery at 80°F can deliver 25 amperes and maintain a voltage of 1.75 volts per cell (10.2 volts total for a 12-volt battery). The reserve capacity rating defines the length of time a vehicle can be driven after the charging system fails.

Ampere-Hour Rating

The oldest battery rating method, and the one with which most people are familiar, is the ampere-hour method. The ampere-hour method is also called the 20-hour rating method. This rating represents the steady current flow the battery will deliver for 20 hours at a temperature of 80°F without cell voltage falling below 1.75 volts. This is equivalent to 10.5 volts for a 12-volt battery. For example, a battery that will continuously deliver 3 amperes for 20 hours is rated as a 60 ampere-hour battery.

Watts Rating

A battery may also be rated by watts, which represents the available cranking power. The watts rating is determined by multiplying the current available from the battery by the battery voltage at 0°F.

Electrical Competencies - Batteries

No. B-2 Visual Inspection

Worksheet # 1

Name ______________________________ Date ____________ Grade __________

The first step in testing a battery is to make visual tests of the battery and related components. Refer to information sheet #1.

	OK	Needs Service or replacement
1. Level of Electrolyte		
2. Condition of Battery Case		
3. Condition of Battery Hold-downs		
4. Condition of Battery Cable Ends		
5. Condition of Battery Posts		
6. Condition of Battery Filler Caps		
7. Condition of Battery Top		
8. Condition of Battery Trays		
9. Condition of Battery Heat Shields		

Instructor's Initials ________

AUTO MECHANICS

Electrical Competencies - Batteries

No. B-3 Battery Maintenance and Cleaning

OBJECTIVE: After completing this exercise you will be able to perform battery maintenance and cleaning.

EXPLANATION: Certian routine operations must be performed to keep the battery in good working condition.

MATERIALS NEEDED: Battery, baking soda, water

TOOLS NEEDED: Battery lift strap,post and terminal cleaning brush, wire brush, battery filler, paint brush, battery terminal puller, cable-clamp spreader, battery pliers and suitable wrenches.

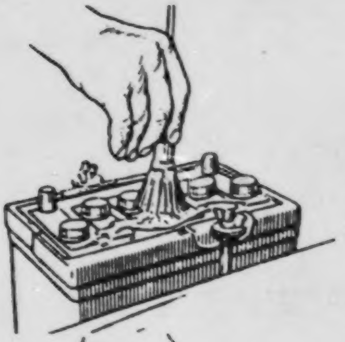
References	Do
#1.Ch. 22 p. 2,10	1. Read assigned reference
#2. --	2. Read information sheets
#3. p.679,682-684	3. Complete worksheet # 1
#4. --	4. Check with instructor
#5. p. 158-160	5. Perform necessary cleaning and maintenance operations using work sheet #2.
#6. p. 255, 261	
#7. Ch. 19,p224,225,229,230	
#8. Ch.3,p.72-77	

No. B-3 Battery Maintenance and Cleaning

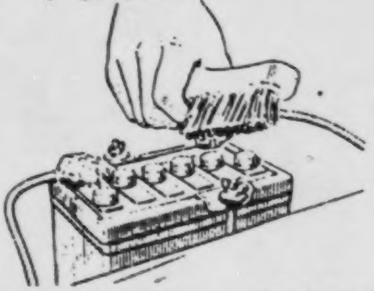
Information Sheet # 1

Battery Cleaning

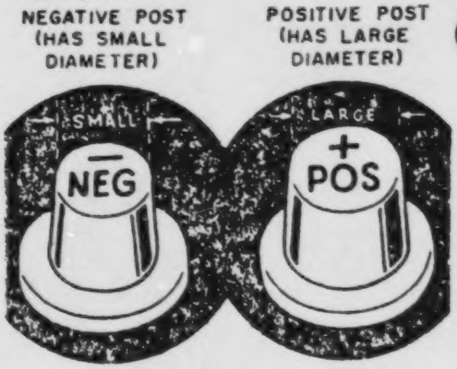
Begin cleaning the battery and cables by neutralizing acid corrosion on terminals,connectors, and other metal parts with a solution of baking soda and water. Be careful to keep corrosion off painted surfaces and rubber parts. DO NO LET THE SODA SOLUTION ENTER THE BATTERY. Remove heavy corrosion with a stiff-bristled brush. Avoid splashing. Dirt and grease can be removed with a detergent solution or solvent. Remove battery for cleaning if corrosion is severe.



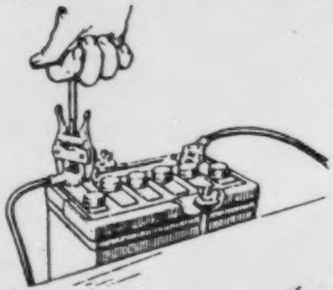
After corrosion is completely neutralized and dirt is washed off, rinse the battery and cable connections with fresh water. Dry with a clean cloth or low-pressure compressed air. If battery terminals and cable connectors are badly corroded, the cables should be removed from the battery for horough cleaning. BEGIN BY REMOVING THE GROUND CABLE FIRST.



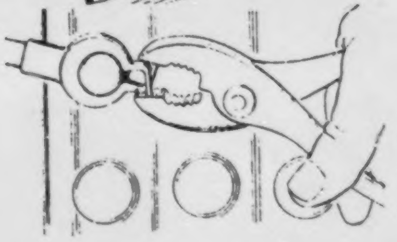
The negative terminal post of the battery is smaller than the positive terminal post.


NEGATIVE POST (HAS SMALL DIAMETER)
POSITIVE POST (HAS LARGE DIAMETER)
SMALL
LARGE
— NEG
+ POS

Use a cable puller to remove a cable that is stuck on a post. Do not pry it off with a screwdriver or hit it with a hammer.

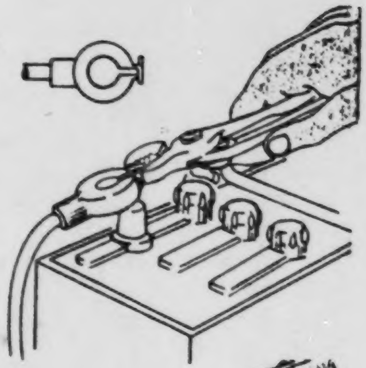


Use a connector-spreading tool to open the cable connector and ream the inside. Neutralize acid corrosion on the cable connectors with a baking soda solution. A combination wire brush with internal and external bristles is a convenient tool for cleaning battery posts and the inside of cable connectors. Be sure the posts and connectors are completely clean for good electrical contact when reinstalled.

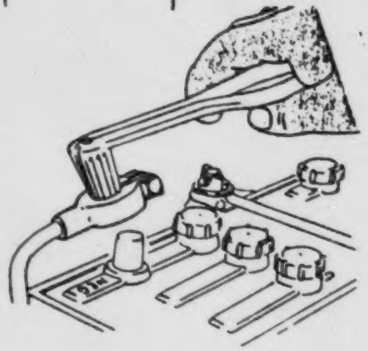


Connect the insulated (hot) cable to the battery first, then the ground cable. The connector should be flush with, or a little below, the top of the post. Do not hammer a connector onto a post; spread it with the correct tool to get the right clearance before installation. Tighten connectors securely. A light coating of petroleum jelly or conductive grease applied to the connectors after installation will help prevent corrosion. Make sure crease is not applied between clamp and post, causing poor contact.

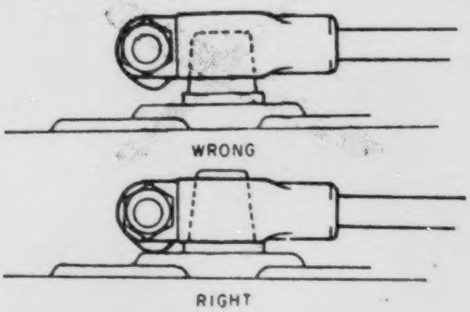
Using pliers to lossen a spring-ring type cable clamp from a battery terminal.



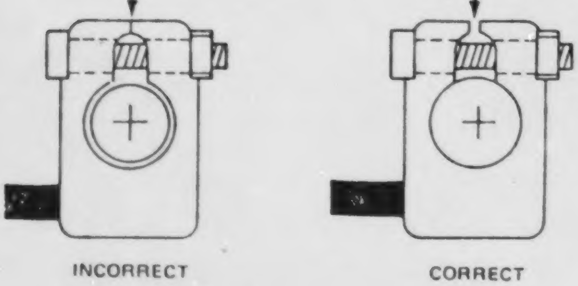
Using a cable-clamp spreader to spread clamp and thus ensure good seating of the clamp on battery terminal post.



Wrong and right ways to put a cable clamp on the terminal post.



If there is no gap between the jaws of the clamp (left), the clamp is probably loose on the terminal post.

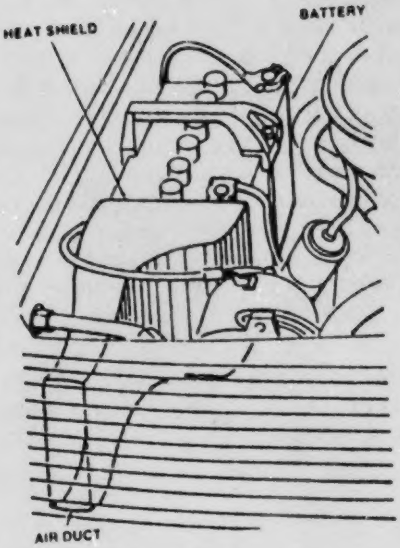


Electrical Compentencies - Batteries

No. B-3 Battery Maintenance and Cleaning

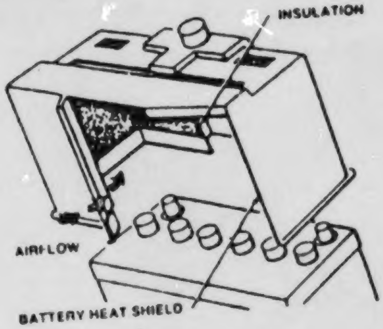
Information Sheet # 2

Battery Heat Shields



Battery heat shield first appeared on some domestic cars in 1972, and their use has been growing steadily since then. Many late-model cars have these shields to protect batteries from high under-hood temperatures.

Most heat shields are made of plasic materials. Some are integral with the battery holddown. These integral shields are usually in the form of a large plastic plate that sits alongside the battery.

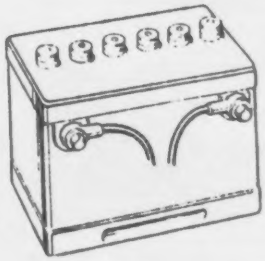


On some cars, the battery is close to the exhaust manifold. Heat shields or this type of installation often include an air duct to direct cooling airflow from the grille to the battery. On other cars, the battery is located closer to the front of the engine compartment, and a special opening is cut in the radiator bulkhead for cooling airflow to the battery.

Heat shields do not require removal for normal battery inspection and testing. However, when a battery is replaced, all of the heat shield parts must be correctly reinstalled.

Side-Terminal and Maintenance-Free (Sealed) Batteries

Many original equipment and replacement batteries for late-model cars have terminals on the side of the case rather than on the top. The side terminals have internal threads, and the battery cables have special connectors with captive bolts. This type of battery is required for underhood clearance on some cars. This design is also said to reduce battery terminal corrosion. Testing and service procedures for side-terminal batteries are generally the same as for batteries with the more familiar post terminals.



Many battery manufacturers are now productng sealed, maintenance-free batteries. These batteries have no cell caps,and water cannot be added. The battery case has a small vent hole to relieve internal gas pressure. Maintenance-free batteries are made with either side or top terminals and usually have a state-of=charge indicator that gives a general indication of the electrolyte specific gravity. These batteries can be tested with a load test as described later in this chapter.

MAINTENANCE FREE

TESTING THE MAINTENANCE-FREE BATTERY

TEST INDICATOR

The test indicator is to be used with accepted diagnostic procedures **only**. It is not to be used to determine if the battery is good or bad, or charged or discharged. The test indicator is a built-in hydrometer in one cell and provides visual information for battery testing.

STEP 1. Visual Inspection

Check for obvious damage such as cracked or broken case or cover that could permit loss of electrolyte. If obvious physical damage is noted, replace battery. Determine cause of damage and correct as needed.

STEP 2. Test Indicator

a. **GREEN DOT VISIBLE** (Figure 1)
Proceed to Step 4. NOTE: On rare occasions, after prolonged cranking, the **green dot** may still be visible. Should this occur, charge battery as described in "Battery Charging Procedures" section, then proceed to Step 3.

b. **DARK—GREEN DOT NOT VISIBLE** (Figure 2)
Charge the battery as outlined under "Battery Charging Procedures" section and proceed to Step 3.

On rare occasions, the test indicator may turn light yellow. In this instance the battery should **not** be tested. Replace the battery.

STEP 3. Remove Surface Charge

Connect 300-ampere load across terminals for 15 seconds to remove surface charge from the battery. If Freedom Battery is in vehicle, connect to terminals. If out of vehicle, attach load clamps to adapter charging tool as shown (Figure 3 on page 36). For Delco 1200, remove cables, attach lead alligator clamps to contact lead pad as shown (Figures 4 and 5 on page 36).

STEP 4. Load Test

a. Connect voltmeter and specified load across terminals.

MODEL	LOAD*	MODEL	LOAD*
49-5	210 Amperes	85-4	130 Amperes
55-5	180 Amperes	85-5	170 Amperes
59-5	210 Amperes	87-5	210 Amperes
71-5	230 Amperes	89-5	230 Amperes
81-5	230 Amperes	1200	235 Amperes

*See "Charging & Testing Adapters" section

b. Read voltage after 15 seconds with load connected, then disconnect load.
c. If minimum voltage is 9.6** or more, battery is good.
d. If minimum voltage is less than 9.6**, replace battery.
**This voltage is to be used for battery ambient temperatures of 70°F and above. For temperatures below 70°F, use the following:

	(21°c) 70°F & Above	(16°c) 60°F	(10°c) 50°F	(4°c) 40°F	(−1°c) 30°F	(−7°c) 20°F	(−12°c) 10°F	(−18°c) 0°F
Minimum Voltage	9.6	9.5	9.4	9.3	9.1	8.9	8.7	8.5

No. B -3 Battery Maintenance and Cleaning

Worksheet # 1

Name ______________________ ___________ Date _______________ Grade________________

T. F. 1. The battery ground cable should be removed first.

T. F. 2. Pure tap water or distilled water must be used for filling a battery.

T. F. 3. If you don't have a cable puller, a hammer and large screwdriver would work for removing cable ends.

T. F. 4. Dirt and corrosion may be removed from the top of a battery with baking soda and water.

T. F. 5. If you get baking soda into the cells, the battery will be stronger.

T. F. 6. Use a large screwdriver to spread the cable clamp.

T. F. 7. A terminal cleaner will have internal and external bristles for cleaning both the cable clamp and battery post.

T. F. 8. Tighten battery hold-down bolts as tight as you can get them.

T. F. 9. Putting a light coat of grease or petroleum jelly on battery cable clamps and posts will retard the formation of corrosion.

T. F. 10. Battery heat shields are to be used only with the original equipment battery.

Instructors initials __________

Electrical Competencies - Batteries

No. B-3 Maintenance and Cleaning of Batteries

Worksheet # 2

Name ______________________________ Date ____________ Grade __________

WORK COMPLETED

A. Cleaning ____________

1. Battery Case ____________

2. Remove cables from posts ____________

3. Battery posts ____________

4. Cable clamps ____________

5. Tray/Box ____________

B. Maintenance

1. Replace/service cable ends ____________

2. Fill battery--water ____________

3. Remove and replace tray, box, or heat shield ____________

4. Lubricate battery post and clamp with petrolem jelly ____________

Instructor's Initials ____________

AUTO MECHANICS

Electrical Competencies - Batteries

No. B-4 Specific Gravity Test

OBJECTIVE: After completing this exercise you will be able to perform a specific gravity test on an automotive battery.

EXPLANATION: The specific gravity of the battery will indicate the state of charge of the battery. This test must be performed before proceding to any further testing.

MATERIALS NEEDED: Battery

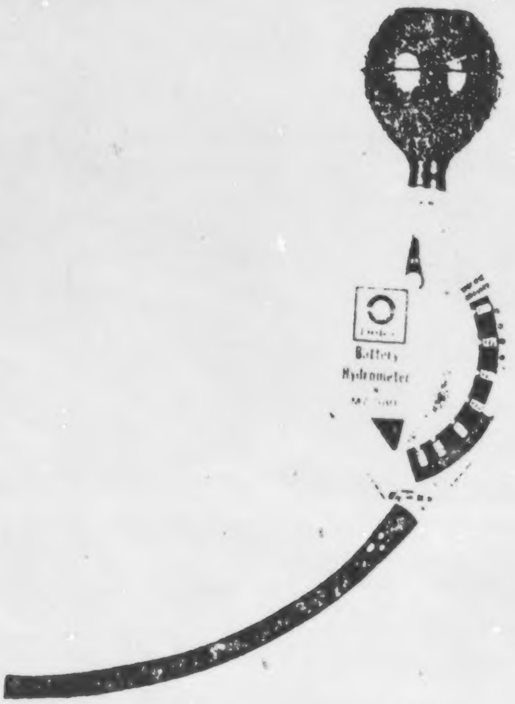
TOOLS NEEDED: Hydrometer, Fender cover

References	Do
#1. Ch.22 pp. 3&4	1. Read assigned references
#2. p. 374-5	2. Study information sheet I
#3. p. 663-5	3. Note information on Information Sheet #1, page 2.
#4. p. 442-3	4. Remove battery caps
#5. p. 156-7	5. Draw electrolyte in hydrometer until the float begins to float.
#6. p. 255-8	6. Read at eye level! Be careful not to drip electrolyte on yourself or vehicle.
#7. p. 226-7	7. Complete worksheet #1.
#8.p62-3	

Electrical Competencies- Batteries

No. B-4 Specific Gravity

Information Sheet # 1

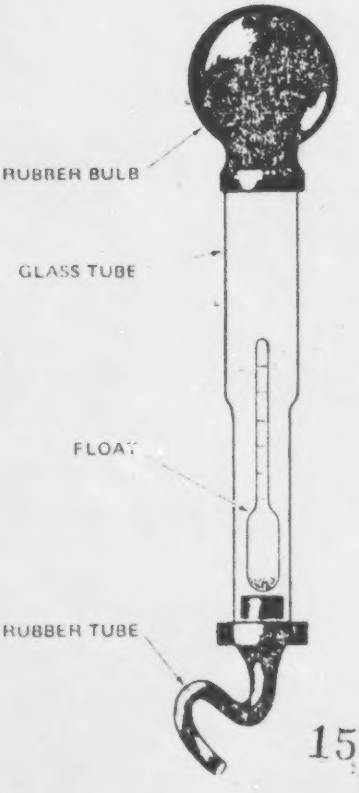


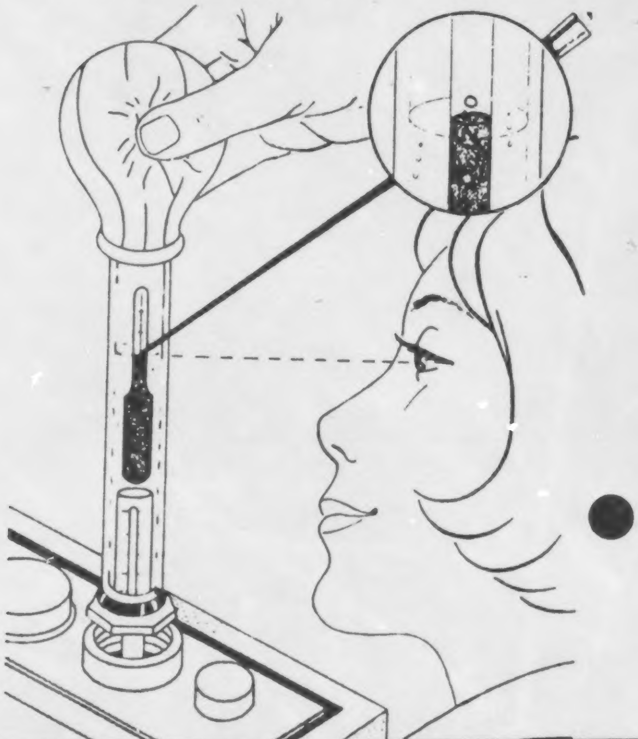
Hydrometer Test. The hydrometer tests the specific gravity, or gravity, of the battery electrolyte. It has a rubber bulb at the top, a glass tube, a float, and a rubber tube at the bottom. You use it by squeezing the bulb, putting the end of the tube into the battery cell, and then releasing the bulb. This will suck electrolyte up into the glass tube. The float, with its stem projecting, will float in this electrolyte. You can gauge the battery's state of charge by the length of the stem that sticks out of the electrolyte. Take the reading at eye level, as shown.

CAUTION: DO NOT DRIP ELECTROLYTE ON THE CAR OR ON YOURSELF! IT WILL RUIN THE PAINT ON THE CAR AND EAT HOLES IN YOU CLOTHES!

If the float sticks out so the reading on the stem is between 1,260 and 1,290, the battery is fully charged. If the reading at the electrolyte level is between 1,200 and 1,230, the battery is only half charged. If the reading is around 1,140, the battery is run down and needs a recharge. The following list of specific-gravity readings gives you a general idea of battery condition.

1,265-1,299	Fully charged battery
1,235-1,265	Three-fourths charged
1,205-1,235	One-half charged
1,170-1,205	One-fourth charged
1,140-1,170	Barely operative
1,110-1,140	Completely discharged

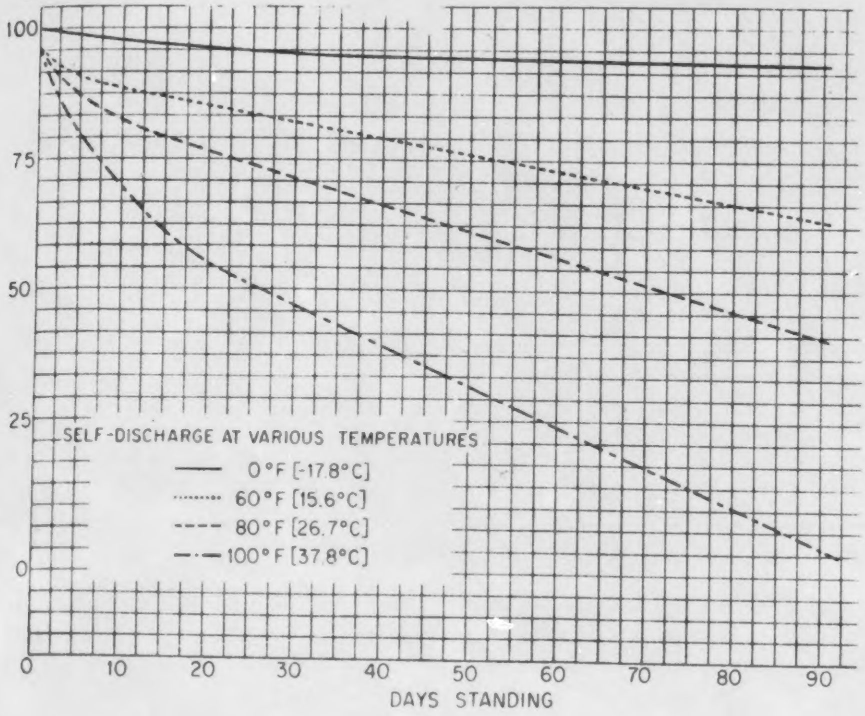




If some cills test quite a bit lower than, others, it means there is something wrong with those cells. It could be that a cracked case has allowed electrolyte leakage, or perhaps there is internal damage to the plates or separators. If the variation is only a few specitic-gravity points, then there is probably no cause for alarm. But if cells measure 25 to 50 points lower, then those cells are defective and the battery should be replaced.

Variation of Gravity with Temperature

Varying states of charge, as we have seen, affect the gravity, and temperature also changes the gravity. As a liquid cools, it becomes thicker and gains gravity. As a liquid warms, it becomes thinner and loses gravity. Thus, temperatures must be considered when a gravity reading is taken. A correction must be made if the temperature varies from standard. This correction involves the addition or subtraction of gravity points, according to whether the electrolyte temperature is above or below the 80 degrees Fahrenheit (26.7C) standard. The gravity of electrolyte changes about four points, or four thousandths (0.004), for every 10 degrees Fahrenheit (6.5C) changes in teimpeiature. To make temperature correction, four points must be subtracted for every 10 degrees Fahrenheit below 80 degrees Fahrenheit (26.7 C). Four points must be added for every 10 degrees above 80 degrees Fahrenheit (26.7 C). EXAMPLE: 1.250 at 120 degrees Fahrenheit (48.9 C): Add 0.016 (4 x 0.004). Corrected reading is 1.266. 1.230 at 20 degrees Fahrenheit (-6.7 C): Subtract 0.024 (6 x 0.004). Corrected reading is 1.206



Loss of Gravity from Self-discharge

There is always some chemical activity in a battery even though the battery is not connected to a circuit and delivering current. Such chemical action, which does not produce current, is termed self-discharge. Self-discharge varies with temperature and strength of electrolyte. As might be expected, the higher the temperature, the faster the self-discharge, since the chemical actions are stimulated by the higher temperatures. Note that the battery kept at 100 degrees Fahrenheit (37.9 C) loses half its charge in 30 days, while the battery kept at 0 degrees Fahrenheit (-17.8 C) suffers almost no loss of charge.

A strong electrolyte, with its higher percentage of sulfuric acid, also causes more rapid self-discharge. This was shown by the more rapid dropping off of the curves during the first few days of the test when the electrolyte was the strongest. The lead sulfate produced by self-discharge is harder to break down during recharging of the battery. If batteries are not recharged periodically to compensate for self-discharge, they may be severely damaged or even completely ruined.

Older batteries and batteries that have impurities in them (often introduced in the water) tend to self-discharge more rapidly.

Appearance of the charge indicator in the top of some sealed, of no-service batteries. (a) If the green dot shows, the battery is in a charged condition. (b) If the indicator shows black, the battery is low. (c) If the indicator shows white, the battery has lost electrolyte and should be considered defective.

Loss of Gravity from Age

As the battery ages, the electrolyte gradually loses gravity. This is because active material is lost from the plates (as it sheds and drops into the bottom of the cells) and because gassing causes the loss of acid. Over a period of 2 years, for example, battery electrolyte may drop to the top gravity, when fully charged, of not more than 1.250 from the original top gravity of 1.290. Little can be done to restore gravity, since the losses are an indication of an aging battery.

Freezing Point

The higher the gravity, the lower the temperature required to freeze the electrolyte. Freezing must be avoided, since it will usually ruin the battery.

The lesson we can gather from this table is that a run-down battery must never be left out in the cold. Sometimes in winter, a person may try to start a car and do nothing more than run the battery down. If the car remains out in the cold, the battery may freeze. Then a new battery will have to be installed and the original trouble corrected.

CAUTION: SOME OF THE NEWER 12-VOLT PASSENGER-CAR-TYPE BATTERIES HAVE SUFFICIENT CAPACITY, EVEN WITH A LOW GRAVITY READING, TO CRANK THE ENGINE. THUS, EVEN THOUGH THESE BATTERIES ARE STILL ABLE TO CRANK THE ENGINE, THE SPECIFIC GRAVITY OF THE ELECTROLYTE CAN BE SO LOW THAT THE ELECTROLYTE WILL FREEZE AT COMPARATIVELY MILD TEMPERATURES. THEREFORE, WITH THESE BATTERIES THE ABILITY TO CRANK CANNOT BE RELATED TO RESISTANCE TO FREEZING.

Specific Gravity	Freezing Temperature, Degrees Fahrenheit (C)
1.100	18 (-8)
1.160	1 (-17)
1.200	-17 (-27)
1.220	-31 (-35)
1.260	-75 (-59)
1.300	-95 (-71)

Battery Gravities for Hot Climates

Batteries operating in hot climates are often readjusted so that their gravity is reduced. Instead of a 1.290 gravity, for example, the electrolyte may be reduced to as low as 1.230 (31 percent acid),dumping the electrolyte, and replacing it with 1.230 specific gravity electrolyte. Or part of the electrolyte may be removed and water added until the gravity is reduced to the proper value. The reduction of the gravity in the manner prolongs the life of the battery and reduces the amound of self-discharge. On discharge, the gravity may drop as low as 1.075 before the battery ceases to deliver current. Where there is not danger of freezing, these lower gravities may be used with safety. NOTE: Some late-model 12-volt batteries for passenger-car service have a somewhate lower specific gravity when charged. For instance, one type is fully charged with a specific gravity of 1.270. Other batteries- for example, those used in hot climates- have a specific gravity of 1.225 when fully charged.

The decimal point is not normally referred to in a discussion of specific gravity. For example, "twelve twenty-five" means 1.225, and "eleven fifty" means 1.150. Also the word "specific" is dropped, so that the term becomes just "gravity".

Electrical Competencies- Batteries

No. B-4 Specific Gravity Test

Worksheet # 1

Name ______________________ Date __________ Grade __________

NOTE: This test cannot be performed on maintenance free batteries.

1. Battery Specific Gravity Test

   a. Cell #1 reading ______________ Temperature Correction

   b. " #2 reading ______________ " "

   c. " #3 reading ______________ " "

   d. " #4 reading ______________ " "

   e. " #5 reading ______________ " "

   f. " #6 reading ______________ " "

   g. Cell variation below .050 Yes __________ No __________

2. Batteries state of charge

   ________ a. Full

   ________ b. 3/4

   ________ c. 1/2

   ________ d. 1/4

   ________ e. Discharged

3. Should this battery be:

   ________ a. Charged

   ________ b. Given a capacity test

   ________ c. Returned to service

   ________ d. Replaced

Instructor's Initials ______

AUTO MECHANICS

Electrical Competencies - Batteries

No. B-5 Battery Capacity Test

OBJECTIVE:
After completing this exercise you will be able to perform a capacity load test on an automotive battery.

EXPLANATION:
A capacity test will determine how a battery performs under load. The chart in the information sheet will help you understand the procedure.

MATERIALS NEEDED:

Battery- at or near full charge.

TOOLS NEEDED:
Ammeter, Voltmeter, Fixed or Variable Resistance pile.

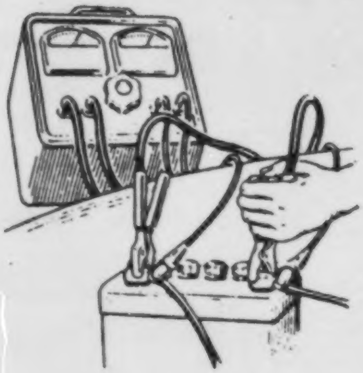
References	Do
#1. p. 22-25	#1. Read assigned references.
#2. Ch. 19, p.365	#2. Study information sheets.
#3. p. 666-667	#3. Complete worksheet #1
#4. p. 443	#4. Turn to work sheet #2. Determine state of charge and record it.
#5. p. 157	#5. Make sure battery is warm.
#6. p. 258	#6. Determine size of battery either amp hour rating or cold cranking power and record it
#7. Ch.19, 227-228	#7. Proceed with the capacity test completing worksheet #2
#8. p.65	

No. B-5 Capacity Test

Information Sheet # 1

Capacity Load Test

A capacity test determines how a battery will perform under load. It indicates battery capability to furnish starting current and still maintain sufficient voltage for the effective operation of the ignition system. A test instrument called a battery starter tester is used to conduct the test. It consists of an ammeter, a voltmeter, and either a fixed or variable resistance pile.



Be sure to follow the test equipment manufacturer's instructions for hooking up the tester leads and for conducting the test. The test can be made with the battery in or out of the vehicle. Electrolyte temperature should be approximately 80°F, and the battery at, or near, full charge. A cold battery will show a considerably lower capacity.

1. With the tester control off, connect the tester leads to the battery. Observe correct polarity and be sure that the lest leads contact the battery post correctly. Special adapters may be required to connect the tester to a side-terminal battery.

2. Refer to battery specifications to determine the ampere-hour rating of the battery being tested.

3. Turn the tester control knob to draw battery current at a rate equal to three times the battery's ampere-hour rating determined in step 2. For example: if the battery is rated at 80 ampere-hours, current draw is adjusted to 240 amperes.

4. Maintain this load for 15 seconds while observing the voltmeter. Turn the control knob off emmediately after 15 seconds of current draw.

5. Voltage should not fall below 9.6 volts for a 12 -volt battery or 4.8 volts for a 6-volt battery.

Alternative Capacity Test

If a battery starter is not available, the starter motor can be used as a battery loading device to conduct a capacity test.

1. Lift the coil high tension lead from the center tower of the distributor cap and ground it with a jumper.

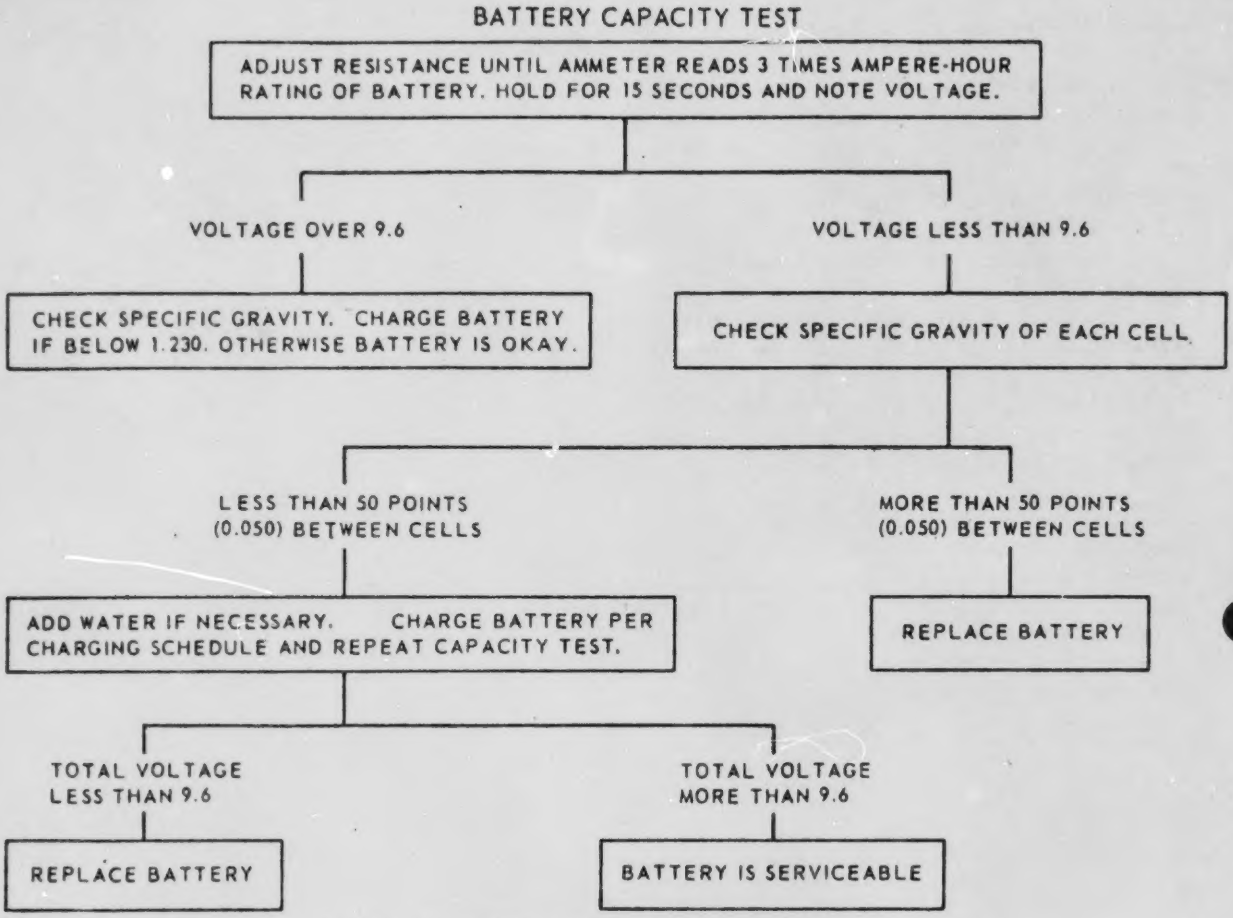
2. Connect a voltmeter to the battery terminals,observing proper polarity.

3. Crank the engine continuously for 15 seconds and observe the voltmeter reading at the end of the period.

4. If the voltmeter reading is 9.6 volts or higher for a 12-volt battery, or 4.8 volts for a 6-volt battery, the battery and cranking circuit are in good condition.

If the voltage reading drops below these values, the battery is defective.

CAPACITY TEST


BATTERY CAPACITY TEST
ADJUST RESISTANCE UNTIL AMMETER READS 3 TIMES AMPERE-HOUR RATING OF BATTERY. HOLD FOR 15 SECONDS AND NOTE VOLTAGE.
VOLTAGE OVER 9.6
CHECK SPECIFIC GRAVITY. CHARGE BATTERY IF BELOW 1.230. OTHERWISE BATTERY IS OKAY.
VOLTAGE LESS THAN 9.6
CHECK SPECIFIC GRAVITY OF EACH CELL
LESS THAN 50 POINTS (0.050) BETWEEN CELLS
ADD WATER IF NECESSARY. CHARGE BATTERY PER CHARGING SCHEDULE AND REPEAT CAPACITY TEST.
MORE THAN 50 POINTS (0.050) BETWEEN CELLS
REPLACE BATTERY
TOTAL VOLTAGE LESS THAN 9.6
REPLACE BATTERY
TOTAL VOLTAGE MORE THAN 9.6
BATTERY IS SERVICEABLE

Battery capacity test recommended by Ford.

Electrical Competencies- Batteries

No. B-5 Battery Capacity Test

Worksheet # 1

Name ______________________ Date __________________ Grade ______________

________ 1. What approximate temperature should the electrolyte be?

________ 2. To test an 80 ampere-hour battery the current draw should be adjusted with resistance pile to how many amperes?

________ 3. How long should the test load in # 3 be applied to the battery?

4. What test or check of the battery should be made if a 12 volt battery reads lower than 9.6 volts during capacity test?

____

________ 5. Is the voltmeter connected in series or parallel with the battery when conducting a capacity test.

Instructors initials ________

No. B-5 Battery Capacity Test

Worksheet #2

Name ______ Date ______ Grade ______

Refer to information sheet and equipment manufacturer's operation manual(s) before completing work sheet.

1. Battery 3/4 or more charged? ______

   Specific gravity 1.230 or more? ______

   Cell variance less than .050? ______

2. Electrolyte temperature approximately 80°F ______

3. 3 times battery ampere hour rating or ½ times cold-cranking rating. ______

4. Load for test ______

5. Voltage after 15 seconds ______

6. If voltage is low, continue testing using chart in information sheet. ______

   a. Specific Gravity

      Cell 1 ______ 4 ______

      2 ______ 5 ______

      3 ______ 6 ______

   b. Charge and retest if specific gravity within specifications.

7. Battery condition: serviceable ______

   replace ______

Instructors initials ______

AUTO MECHANICS

Electrical Competencies - BATTERIES

No. B-6 - 3 Minute charge test

OBJECTIVE: At the completion of this unit, the student will be able to perform the 3 minute charge test.

EXPLANATION: This test should be used on batteries that have failed the capacity test to determine if the battery could be recharged or if the plates are to badly sulphated.

MATERIALS NEEDED: Battery

TOOLS NEEDED: Battery Charger, Voltmeter

References	Do
#1. Ch.22 p.10	1. Read assigned reference
#2. --	2. Study Information sheet
#3. --	3. Check with instructor
#4. --	4. Perform 3 minute charge test using work sheet # 1
#5. --	
#6. --	
#7. --	
#8. p. 66-7	

Electrical Competencies- Batteries

No. B 6 3 Minute Charge Test

Information Sheet # 1

A three-minute charge test can be made on a discharge battery to determine whether the battery can be recharged or whether it is too badly sulfated to accept a charge. A fast battery charger is used to pass a high charging current through the battery for three minutes. If the battery is not badly sulfated, the high current will knock the sulfate deposits off of the plates. If the battery is too badly sulfated to accept a fast charge, the sulfate will not be dislodged, and excessive voltage will be recorded across the battery terminals.

If the battery is to be tested in the car, disconnect both battery cables to avoid damaging the alternator and electrical system. CAUTION: If high voltage is recorded early in the test, stop the test. High internal resistance due to sulfated or shorted plates will develop excessive heat that can boil the electrolyte. Perform the three-minute charge test as follows:

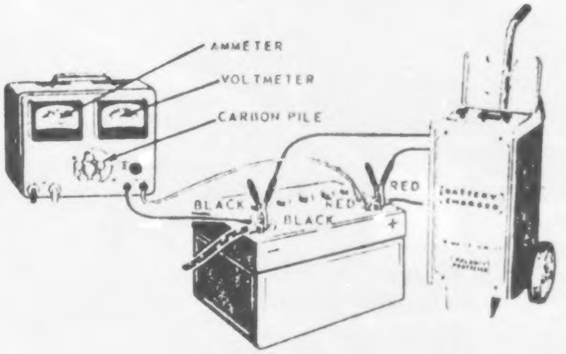
1. Connect the charger leads to the battery, observing the correct polarity.

2. Connect voltmeter to battery posts, observing the correct polority and correct voltage scale.

3. Turn the charger on and adjust it for the highest charging rate but not exceed 40 amperes for a 12-volt battery or 75 amperes for a 6-volt battery. If the charger has a timer, set it for 3 minutes.

4. After 3 minutes, read the voltmeter. If it does not exceed 15.5 volts for a 12-volt battery or 7.75 volts for a 6-volt battery,the battery can be safely recharged at the manufacturer's recommended charging rate.

5. If the voltage reading exceeds the values given in step 4, the battery is internally defective and should be replaced.



Connections for 3 minute charge test.

Electrical Competencies- Batteries

No. B-6 3 Minute Charge Test

Worksheet # 1

Name ____________________ Date ______________ Grade ______________

1. Battery voltage: Specified ____________ Voltmeter ______________

2. From either specific gravity test or capacity test is the battery at least 3/4 discharged? ____________

3. Battery voltage after 3 minute charge ____________
(rate: 40 amp. for 12 volt, 75 amp. for 6 volt)

4. Is battery:
   a. Rechargable __________
   b. Sulphated __________

5. Explain why you answered number 4 either a or b.

____

____

____

Instructor initial ______

AUTO MECHANICS

Electrical Competencies- Batteries

No. B-7 Individual Cell Voltage

OBJECTIVE:

After completing this exercise you will be able to perform individual cell voltage test.

EXPLANATION:

The individual cell voltage test can be used to determine voltage variation between cells and state of charge.

MATERIALS NEEDED:

Battery

TOOLS NEEDED:

Individual cell voltage test equipment

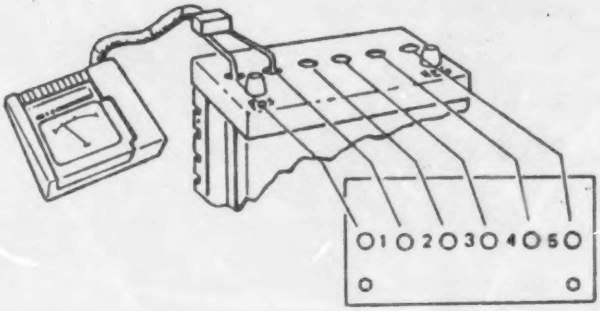
References	Do
#1. --	#1. Read assigned references
#2. --	#2. Study information sheets
#3. --	#3. Refer to equipment manufactures operating instructions
#4. p. 444	#4. Complete worksheet
#5. --	
#6. Ch. 27, p. 258-259	
#7. Ch. 19, p. 229	
#8. Ch. 3, p.67	

No. B-7 Individual Cell Voltage Test

Information Sheet # 1

Cadmium-Tip Test

The cadmium-tip test requires a special tester with cadmium tips that are inserted into the electrolyte of adjacent cells after the filler plugs have been removed. Electrolyte must be up to the proper level. If the car has been operated or the battery charged within 8 hours, turn on the headlights for 1 minute. Then turn the headlights off. Start the test by putting the red probe into the end cell that has the positive terminal and the black probe into the adjacent cell. Note the meter reading. Move probes to cells 2 and 3 and so on along the battery, noting meter readings between all cells. Compare readings.



1. If any two cells vary five scale divisions or more (on top scale), the battery is at the point of failure and should be replaced. Figure A

2. If all cells vary less than five scale divisions and all read in the green section, the battery is charged and in good condition. Figure B

3. If all cells vary less than five scale divisions but if any fall in the red section, the battery is in good condition but needs charging. Figure C

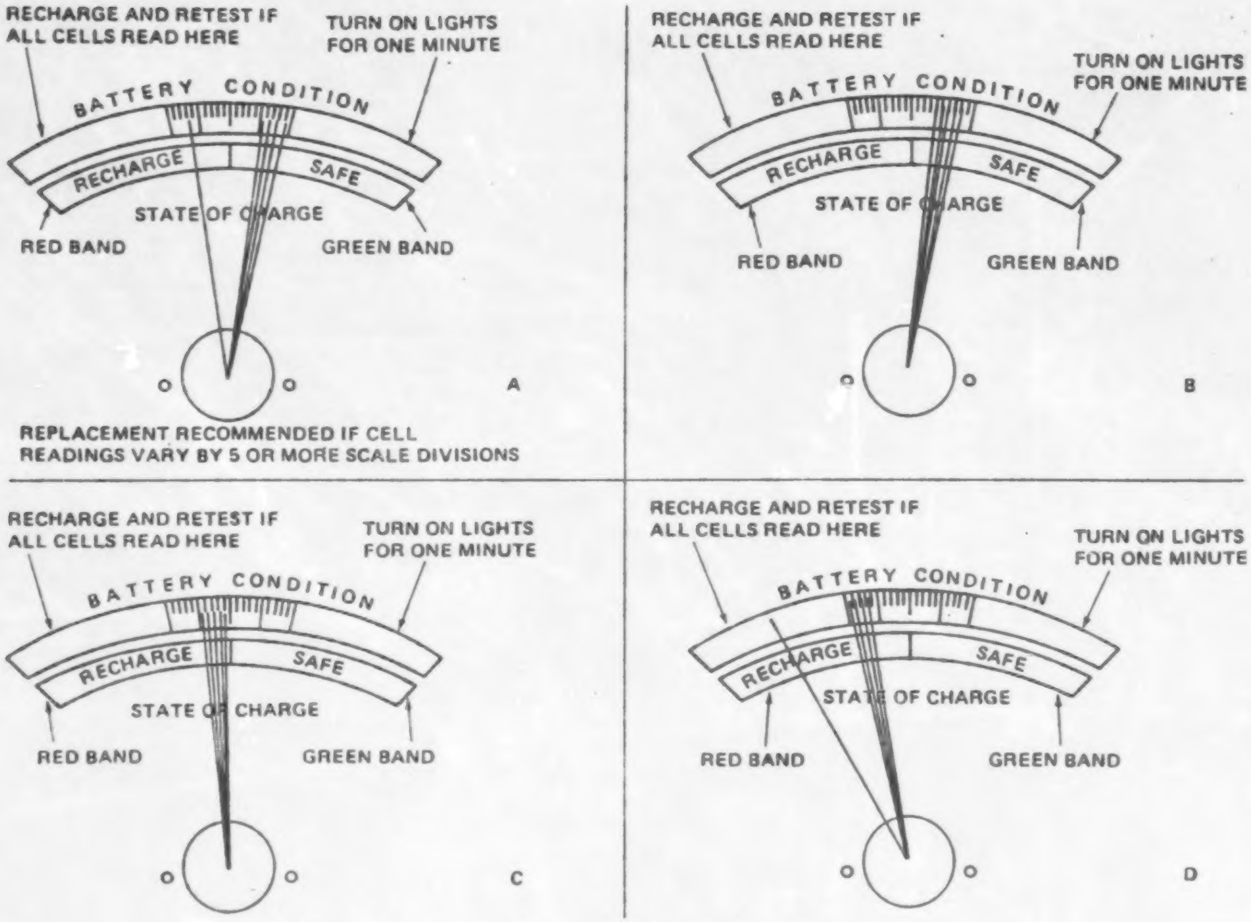
4. If any reading falls into the recharge-and-retest area, the battery is too low to make a good test. Recharge and retest it. Figure D

Figures A, B, C, D on page 2.

Electrical Competencies- Batteries

No. B-7 Individual Cell Voltage Test

Information Sheet #1
Page 2.


RECHARGE AND RETEST IF ALL CELLS READ HERE
TURN ON LIGHTS FOR ONE MINUTE
BATTERY CONDITION
RECHARGE
SAFE
STATE OF CHARGE
RED BAND
GREEN BAND
A
REPLACEMENT RECOMMENDED IF CELL READINGS VARY BY 5 OR MORE SCALE DIVISIONS
RECHARGE AND RETEST IF ALL CELLS READ HERE
TURN ON LIGHTS FOR ONE MINUTE
BATTERY CONDITION
RECHARGE
SAFE
STATE OF CHARGE
RED BAND
GREEN BAND
B
RECHARGE AND RETEST IF ALL CELLS READ HERE
TURN ON LIGHTS FOR ONE MINUTE
BATTERY CONDITION
RECHARGE
SAFE
STATE OF CHARGE
RED BAND
GREEN BAND
C
RECHARGE AND RETEST IF ALL CELLS READ HERE
TURN ON LIGHTS FOR ONE MINUTE
BATTERY CONDITION
RECHARGE
SAFE
STATE OF CHARGE
RED BAND
GREEN BAND
D

Interpretation of meter readings for the cadmium-tip test.

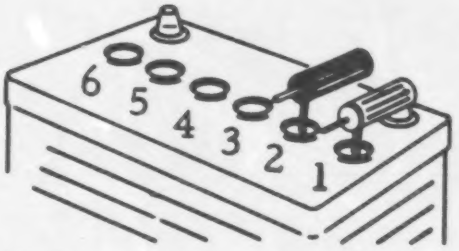
Electrical Competencies - Batteries

No.B-7 Individual Cell Voltage

Information Sheet # 2

Individual cell voltage test using voltmeter and probes, example: Sun vat 28. Note the method of obtaining all 6 readings. Compare this to method use in information sheet 1.

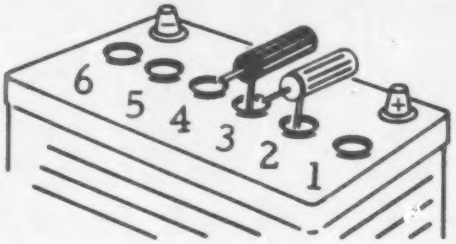
These six steps are used for testing cell voltages under load and during the 3 minute charge test. (Load used during cadacity test)



12-Volt Batteries

Procedure for first five cell readings-

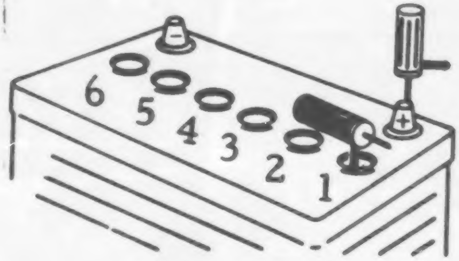
1. Pos. Probe Cell 1) Record or remenber reading Neg. Probe Cell2)



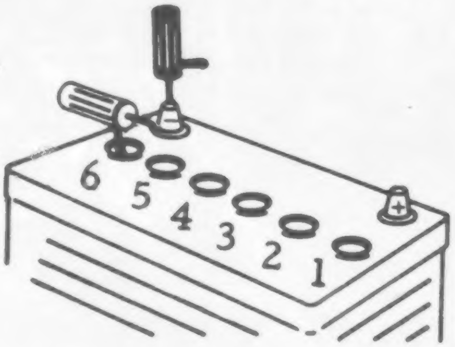
2. Pos.Probe Cell 2) Record or remember reading Neg. Probe Cell 3)
3. Continue in the same manner as above until you have 5 readings. Remember:Pos.Probe follows Neg. Probe. (Red follows Black)

You now have five readings. You need six. Sixth reading takes two steps.

A. Pos.Prod on Pos.Post) Record or remember Neg. Probe in Cell 1) reading



B. Pos. Probe in Cell 6) Record or remember Neg. Prod on Neg. Post)reading



If reading in 3B is to the right of zero on "Voltmeter"add to figure obtained in first step.

If reading in 3B is to left of zero on "Voltmeter"subtract from figure obtained in first step.

You now have the sixth reading.

6 Volt Batteries

Follow steps 1 & 2 above to obtain 2 readings. Follow steps 3A & 3B to obtain 3rd reading.

Electrical Competencies- Batteries

No. B-7 Individual Cell Voltage

Worksheet # 1

Name____________________________________Date____________Grade____________

Refer to material in information sheet and voltage tester manufacturer's operating instructions before completing worksheet. Record cell voltages and determine state of charge and amount individual cell voltages vary.

Reading #	Voltage
1	______
2	______
3	______
4	______
5	______
6	______

What is the maximum variation between cells ____________________________.

What is the state of Charge (is charging needed or should battery be replaced)
____.

Instructor's Initials __________

AUTO MECHANICS

Electrical Competencies- Batteries

No. B-8 Battery Drain Test

OBJECTIVE:

After completing this unit, the student will be able to perform a Battery Drain Test.

EXPLANATION:

The battery drain test is designed to determine if the battery is defective or if another electrical circuit is drawing the charge out of the battery.

MATERIALS NEEDED:

Battery

TOOLS NEEDED:

Wrench
Battery pliers
Terminal Puller
Voltmeter or ammeter

References	Do
#1. --	#1. Read assigned rafference
#2. --	#2. Study information sheet #1.
#3. --	#3. Perform drain test.
#4. --	#4. Complete work sheet #1.
#5. --	#5. Report to instructor.
#6. --	
#7. --	
#8. p. 155-156	

Electrical Competencies - Batteries

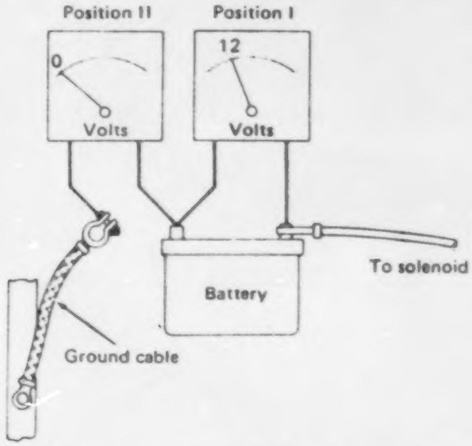
No. B-8 Battery Drain

Information Sheet 1

Occasionally, the electric system develops a very low drain which in time discharges the battery for no apparent reason.

There are many possible causes for a hidden drain on the battery. A hidden drain causes the most damage when the engine is off and when the vehicle is allowed to remain unused for periods of time. A perfect example of hidden drain is the trunk-light switch. If the trunk light remains on, it wll be difficult to detect visually. Another example is a defective brake-light switch. If the diaphragm-type switch, which is subjected to brake line pressure, becomes short-circuited to a point where current trickles to the brake lights at low amperage, it will cause a low battery drain. When this happens, the brake lights may not glow; therefore, there will be no clue to the battery drain.

To detect such drains, remove the ground cable of the battery, connect a voltmeter to the battery according to the correct polarity, and note the battery terminal voltage for future reference. Then connect one voltmeter lead to the battery post according to polarity and the other lead to the removed ground cable. If any circuit is complete, the voltmeter will give a reading of the battery terminal voltage.



(Also see figure on Page 3)

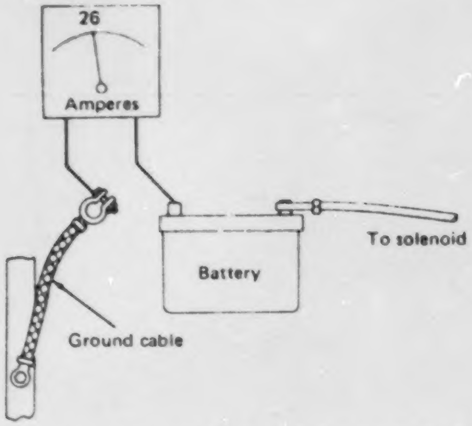
Electrical drain test showing positions I and II of voltmeter.

This test is conclusive only in that in that it shows that some circuit is complete. It is up to you to locate the circuit which is draining. Therfore, the more knowledge you have of the automotive electric circuits, the better your chances of finding the circuit which is draining the battery. One method is to locate the fuse box, remove the fuses one by one, and watch the voltmeter. If it drops back to 0 V or any voltage below battery terminal voltage, you have found the circuit causing the trouble. This circuit will then have to be traced from one end to the other for defective switches and the like.

Do not be fooled by the electric clock, which runs only a few minutes on each electromagnetic winding. While the test is being conducted, the clock could run down during the time the ground cable is disconnected and show up on the test voltmeter as an electrical drain. The clock must be wound before proceeding. This is done by momentarily touching the ground cable back on the battery post from which it was removed. A click will be heard, and the clock will be wound for a few minutes. The voltmeter will drop back to zero or some voltage lower than terminal, and you can then proceed.

No. B-8 Battery Drain

Information Sheet 1
Page 2



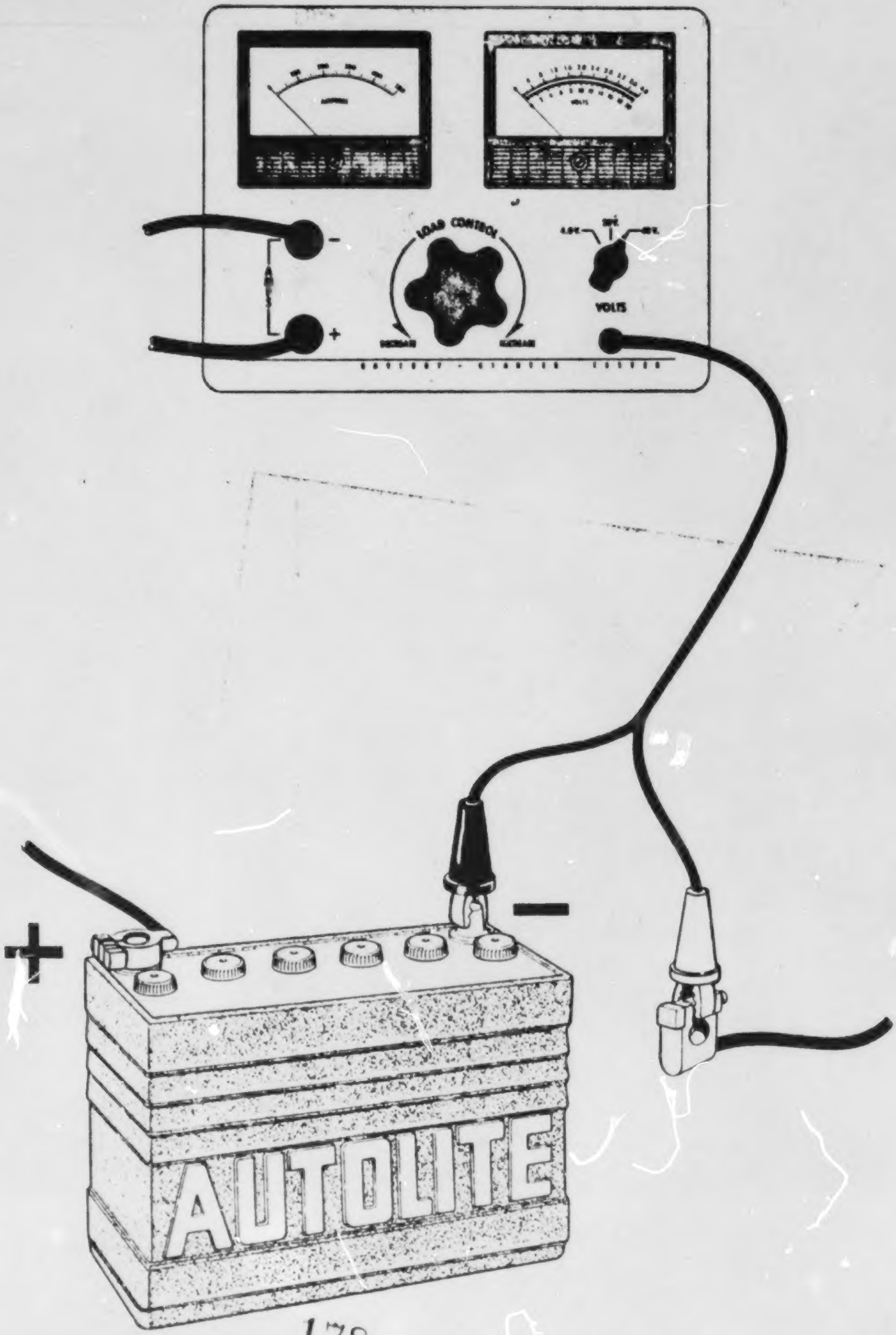
Ammeter position for electric-load check-out.

Sometimes a clue to the circuit draining can be obtained by temporarily substituting an ammeter for the voltmeter, connected in the same way. If there is sufficient current flowing to be readable on the ammeter, the amount of current may give you a clue as to which circuit it is. If the voltmeter reads, showing there is a current drain, and the ammeter does not read, the condition can be considered a low drain or an electrical leak.

Switches have been known to leak, allowing extremely small amounts of current to pass. Remember: This can be detected with the voltmeter but cannot be detected with with the average ammeter. Even if none of the electric circuits are draining, dirt, moisture, and corrosion on the battery, battery box, and hold-down can cause a low drain readable on the voltmeter but probably not readable on the ammeter.

In this case, if the voltmeter reads battery terminal voltage, the low drain is great enough to be corrected by removing the battery and cleaning it by any of the approved methods. Also clean and paint the battery box and hold-down. Install a new hold-down if one is needed.

Other places to look for an electrical drain are the cutout points in the regulator, a shorted diode in the alternator, or a defective radio switch. On Ford vehicles equipped with an electronic regulator, there is slight, harmless, but continuous drain readable on the voltmeter which might lead you to believe that there is trouble. For a valid electric-circuit drain test, the regulator must be disconnected and the test repeated.


−
+
LOAD CONTROL
VOLTS
+
−
AUTOLITE

Electrical Competencies- Batteries

No. B-8 Battery Drain Test Worksheet # 1

Name ________________________________ Date ____________ Grade __________

ELECTRIC-CIRCUIT DRAIN TEST

Year and make ____

Name of owner ____

Battery terminal voltage: _______V

Reading when voltmeter is connected from battery post to ground strap: _______V

Is the voltmeter reading the same as battery terminal voltage?

Yes _______ No _______ (If the answer is yes, there is trouble)

Is the voltmeter reading lower than battery terminal voltage?

No________ Yes________ (If the answer is yes, everything is satisfactory.)

Is ther an ammeter reading? Yes_______ No________

If the answer is yes, how many amperes? ______________________________

If an electrical drain exists, you should begin disconnecting circuits (usually by removing fuses one by one). In which circuit did you find a malfunction?

____

Check with instructor and repair malfunction.

Instructors Initials ________

AUTO MECHANICS

Electrical Competencies -- Batteries

No. B-9 Battery Charging

OBJECTIVE:

After completing this unit, the student will be able to select the correct method of charging a given battery and he will be able to correctly and safely charge that battery.

EXPLANATION:

Frequently batteries are found to be in various stages of discharge and must be recharged to make them serviceable. This unit contains the procedure for restoring a battery to a fully charged state using the various methods available.

MATERIALS NEEDED:

Baking soda
Water
Dry shop towel
Electrolyte if activating a Dry-Charge battery

TOOLS NEEDED:

Battery Charge
Adapters if the battery has side terminals
Hydrometer
Thermometer

References	Do
#1. Ch. 22, p. 6-7	#1. Read Assigned reference.
#2. --	#2. Study information.
#3. p. 684-686	#3. Refer to unit on battery testing to determine condition of battery and method of charging to be used.
#4. p. 444-448	
#5. p. 157	#4. Check with instructor.
#6. p. 261-264	#5. Proceed with charging of battery.
#7. p. 228-229	#6. Complete worksheet.
#8. p. 77-78	#1. For slow charge
	#2. For fast charge
	#3. For sulfated battery
	#4. For activating a dry charged battery

No. B-9 Batteıy Charging

I Safety Precautions for Charging batteries

1. Charge in a well-ventilated area away from sparks and open flame.
2. Be sure the charger is off before connecting or disconnecting cables at the battery.
3. Never try to charge a frozen battery.
4. Wear eye protection
5. If the battery is to be charged in the car,connect the charger cables to the battery, observing the correct polarity. Turn on the charger and set it for the desired rate.
6. Monitor electrolyte temperature closely during charging and stop charging if the temperature rises above 125°F.
7. Never fast charge a battery that has failed a three-minure charge test.
8. A battery with discolored electrolyte (from cycling) or with gravity readings more than 25 points apart should not be quick-charged. Likewise, a badly sulfated battery should not be quick-charged. Such batteries may be near failure, but they may give additional service if slow-charged. However, quick-charging them might damage them further. During quick charging, check the color of the electrolyte. Stop charging if it becomes discolored as a result of the stirring up of washed-out active material. Likewise, cell voltages should be checked every few minutes. Charging should be stopped if cell voltages vary more than 0.2 volt.
9. When quick-charging a battery in a car, disconnect the battery ground strap to protect the electrical system from damage due to high voltage.

II General Information

Battery Charging

Battery charging consists of applying a charging current rate in amperes for a period of time in hours. For example, a 20-ampere charging rate for 3 hours would be a 60-ampere-hour charging input to the battery.

Batteries are usually charged at rates from 3 to 50 amperes. Charging rates at the lower end of this range are considered slow charging. Rates at the higher end of the range are considered fast charging. Fast chargers are the most widely used kind of charging equipment in service stations and garages. Most fast chargers have the capability of charging at either a fast or a slow rate. Many motorists own slow chargers, or "trickle" chargers, that will charge a battery only at a slow rate.

Generally, any battery can be charged at any current rate as long as electrolyte gassing and spewing do not occur and as long as electrolyte temperature stays below 125°F. Whenever time permits, however, the most satisfacotry charging results are obtained at a slow rate of about 5 to 15 amperes.

Whether charging at a slow of fast rate, begin by checking the electrolyte level. It should be about 1/4" above the separators in each cell. Charging with the electrolyte below the separators may damage the battery. Charging with the level too high may cause the electrolyte to overflow from the heat of charging. The proper electrolyte level is particularly important for fast charging. Leave the cell caps in place during charging, but be sure the vent holes are open.

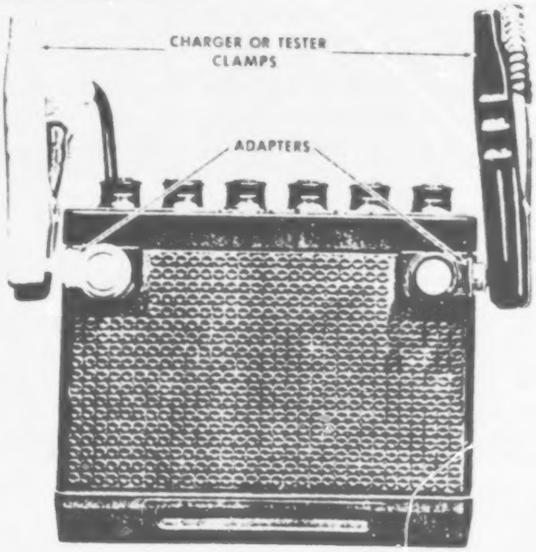
Be sure also that the ac power line to which the charger is connected is delivering full voltage. Do not connect the charger to a heavily loaded circuit. An ac voltage drop of 20 percent can reduce the charger's output by 35-40 percent. If an extension cord is necessary, use a number-14 or larger heavy-duty cord not over 25 feet long. The charger power cord and the extension cord should both be the 3-wire type with grounding capability for the charger case. Special adapters may be required to connect the charger to a side-terminal battery.

Check the specific gravity and electrolyte temperature periodically during charging. Stop charging immediately if the temperature rises above 125°F. Check the voltage across the battery terminals with a voltmeter or a battery tester. If voltage exceeds 15.5 volts for a 12-volt battery of 7.5 volts for a 6-volt battery, lower the charging rate until the voltage drops below these maximum values.

The battery is fully charged when all cells are gassing and the specific gravity does not increase for three consecutive hourly readings. The fully charged specific gravity should be 1.260 to 1.280, corrected for electrolyte temperature, unless otherwise specified by the battery maker. If the specific gravity stabilizes below the maximum value for three hours, the battery is not in optimum condition and will not provide optimum performance.

After charging, wash and dry the battery top to remove any acid deposited by electrolyte gassing. Check the electrolyte level and add mineral-free or distilled water if necessary to bring all cells up to the level marks. Reinstall the battery if removed. Connect the insulated (hot) cable (uaually positive) first, then the ground cable (usually negative).

Adapters may have to be used on batteries with side terminals.



III Slow or "Trickle" Charge

The slow-charge rate should be 7 per cent of the amp-hour rating. A 60 ampere-hour battery would require 4.2 amps of charge. A slow-charge rate of 5 amps for passenger-car batteries is normal. Charging periods of 24 hours or more may be needed to bring the battery to a fully charged condition. The battery is fully charged when the specific gravity does not change for two one-hour checks.

IV Fast or "Quick" Charging

Quick Chargers Quick chargers charge the battery at a high rate (as much as 100 amperes) for a short time- 30-45 minutes. The battery is thus brought to a fair state of charge before the battery temperature increases excessively. The quick-charger method does not seem to harm batteries that are not subjected to excessive temperatures. However, high charging rates combined with battery-electrolyte temperatures above 125 degrees Fahrenheit (51.7°C) are very damaging to a battery.

Quick chargers cannot, as a rule, bring a battery up to full charge in a short time. Suppose a battery has been quick-charged for a short time. If the charging operation is then finished by a slow-charging method, the battery will come up to full charge.

V Charging Sulfated Batteries

Charging Sulfated Batteries When a battery has been allowed to stand for some time without attention, its plates may have become sulfated to such an extent that it will not take a charge in a normal manner. In fact, the battery may be completely ruined. However, an attempt to save such a battery may be worthwhile, especially if it is not too old. Put the battery on charge at half the normal charging rate for 60 to 100 hours to see whether the sulfation can be broken down so that the battery will take a charge. The "water cure" is sometimes recommended (dumping electrolyte, filling with distilled water, and charging), but battery engineers seem to agree that there is little advantage in this method over the slow-charge method.

Usually, in a badly sulfated battery, the plate drids and separators are injured because the sulfate takes more room than the active materials in the plates, and the consequent swelling cracks or breaks the grid structure. A badly sulfated battery may be returned to usable condition, but it can never come back all the way; part of its life has been lost.

VI Use of Jumper Cables

Procedure For Using Jumper Cables

1. Attach RED cable first to the POSITIVE terminal of the DEAD battery, then to the POSITIVE terminal of the booster battery.
2. Attach the BLACK cable first to the NEGATIVE terminal of the LIVE battery and then to an unpainted bolt on the ENGINE BLOCK or motor of the car with DEAD battery.

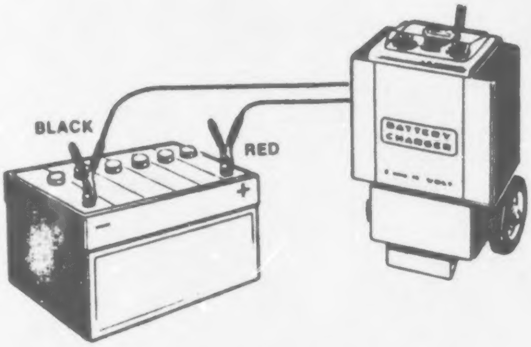
Procedure For Removing Jumper Cables

1. Disconnect cables from the ENGINE BLOCK, then from the NEGATIVE BOOSTER, FROM POSITIVE BOOSTER, and from POSITIVE DEAD BATTERY.

VII Activating Dry-Charge Batteries

To ensure the best possible service, activate a dry-charged battery just before installation. To avoid the possibility of damage from spilled acid, do not activate a battery after installing it in a car.

Fill each cell of the battery to the tops of the separators with the packaged electrolyte. Charge a 12-volt battery at 30-40 amperes or a 6-volt battery at 60-70 amperes until the electrolyte temperature is about 80°F and specific gravity is above 1.250.



After charging, check the electrolyte level. If it is low, add enough electrolyte to bring the level up to the indicated markings in each cell. Therafter, when servicing the battery, add only mineral-free or distilled water to maintain the electrolyte level.

After the battery is properly filled and charged, dispose of excess electrolyte by neutralizing it with baking soda and pouring it down a floor drain or utility sink. Use care in neutralizing the electrolyte to avoid acid burns.

MAINTENANCE-FREE BATTERY CHARGING PROCEDURES

Charging equipment for ordinary batteries is suitable for Maintenance-Free batteries. Always turn off charger before connecting or disconnecting to a battery.

DO NOT CHARGE A BATTERY IF THE **GREEN DOT** IS VISIBLE.

NOTE: On rare occasions following prolonged cranking, the **green dot** may still be visible. Should this occur, a boost-charge of 20 ampere-hours is recommended.

DO NOT CHARGE A BATTERY IF THE TEST INDICATOR IS LIGHT YELLOW

12-VOLT MAINTENANCE-FREE BATTERY CHARGING GUIDE

(Stop charging when the **green dot** appears or
when the maximum charge shown below is reached).

Battery Model	Slow Charging Rate	Fast Charging Rate
55-5; 85-4; 85-5	5A @ 10 Hours 10A @ 5 Hours	20A @ 2½ Hours 30A @ 1½ Hours
49-5; 59-5 71-5; 81-5 87-5; 89-5; 1200	5A @ 15 Hours 10A @ 7½ Hours	20A @ 3¾ Hours 30A @ 2½ Hours 40A @ 2 Hours 50A @ 1½ Hours

TO AVOID DAMAGE, charging rate must be reduced or temporarily halted, if:

1. Battery case feels hot (125°F)
2. Violent gassing or spewing of electrolyte occurs.

After charging in accordance with the tables, even though the **green dot** does not appear, the battery is still sufficiently charged for testing.

CHARGING AND TESTING ADAPTERS

FREEDOM BATTERIES WITH SIDE TERMINALS

Freedom batteries should be charged or tested on-the-vehicle, using the existing terminals. However, when out-of-the-vehicle, adapters for the side terminals are required. Figure 3 page 36 shows one available adapter kit (AC-Delco ST-238).

DELCO 1200 H.D. BATTERIES —

Delco 1200 batteries may be charged or tested either on or off the vehicle, however, the battery terminal hex nuts (AC-Delco 7802) are required for testing and charging.

It is important that the alligator clamps of the tester or charger be placed between the terminal nuts and the lead pads of the terminal studs (Figures 4 or 5) page 36 after the vehicle cables are detached. The alligator clamps should make firm contact with the lead pads.

If this connection cannot be made because of alligator clamp design, then the load for testing must be reduced from 235 amps to 210 amps.

Electrical Competencies- Batteries

No. B-9 Battery Charging

Worksheet # 1
Slow Charge

Name ______________________________ Date ____________ Grade ____________

Battery Capacity: Amp Hour Rating ____________

Cold Cranking Power ______________

State of Charge ______________________

Condition of: Plates ________________

Separators ____________________

List tests and test results that you have on this battery

____

____

____

____

____

____

Is Electrolyte level and color ok? Yes_____ No _____

Method of charging ____________________________________

Why did you select this method? ____

____

____

____

Charging Rate Amps ___________________________

Time ___________________________

Beginning:

Battery Charger Settings Rate____________ Amp at this setting ____________

Timer____________ Temperature of Electrolyte ____________

Later:

Battery Charger Settings Rate ____________ Amp at this setting ____________

Timer____________

Instructors Initials____________

Electrical Competencies- Batteries

No. B-9 Battery Charging

Worksheet # 2
Fast Charge

Name____________________ Date________ Grade______

Battery Capacity: Amp Hour Rating ________

Cold Cranking Power ________

State of Charge __________

Condition of : Plates ________

Separators ________

List tests and test results that you have on this battery

____

____

____

____

____

____

Is Electrolyte level and color ok? Yes____ No____

Method of charging ________ __________

Why did you select this method? ____________________

____

____

____

Charging Rate Amps ____________

Time ____________

Beginning:

Battery Charger Settings Rate_______ Amp at this setting _______

Timer _______ Temperature of Electrolyte _______

Later:

Battery Charger Settings Rate _______ Amp at this setting _______

Timer _______ Instructors Initials _______

Electrical Competencies- Batteries

No. B-9 Battery Charging

Worksheet # 3
Sulfated Battery

Name ________________ Date ________ Grade ______

Battery Capacity: Amp Hour Rating __________

Cold Cranking Power ________

State of Charge ____________

Condition of : Plates ________

Separators __________

List tests and test results that you have on this battery

Is Electrolyte level and color ok? Yes ___ No ___

Method of charging ________________

Why did you select this method? ________________

Charging Rate Amps ____________

Time ____________

Beginning:

Battery Charger Settings Rate ________ Amp at this setting ________

Timer ________ Temperature of Electrolyte ________

Later:

Battery Charger Settings Rate ________ Amp at this setting ________

Timer ________

188

Instructors Initials ________

Electrical Competencies- Batteries

No. B-9 Battery Charging

Worksheet # 4
Activating Dry Charged Battery

Name ____________________ Date __________ Grade __________

Battery Capacity: Amp Hour Rating __________

Cold Cranking Power __________

State of Charge __________

Condition of : Plates __________

Separators __________

List tests and test results that you have on this battery

Is Electrolyte level and color ok? Yes ____ No ____

Method of charging __________

Why did you select this method? __________

Charging Rate Amps __________

Time __________

Beginning:

Battery Charger Settings Rate __________ Amp at this setting __________

Timer __________ Temperature of Electrolyte __________

Later:

Battery Charger Settings Rate __________ Amp at this setting __________

Timer __________ Instructors Initials __________

Electrical Competencies- Batteries

No. Final Test, Batteries

Test #1

1. The latest method of rating a battery is by:
   a. ampere hours
   b. cold cranking power
   c. reserve capacity

2. Regardless of a battery's size, each cell has a voltage of approximately:
   a. 6
   b. 2
   c. 12

3. A hydrometer is used to measure:
   a. voltage
   b. amperage
   c. specific gravity

4. At -20 deg., the capacity of a battery is about ____% of its capacity at 80 deg.
   a. 30
   b. 60
   c. 10

5. When a battery is being fast-charged, electrolyte temperature should not exceed:
   a. 80 deg.
   b. 125 deg.
   c. 212 deg.

6. Electrolyte in a fully discharged battery will begin to freeze at about:
   a. +19 deg.
   b. -10 deg.
   c. +32 deg.

7. A battery operated in an undercharged condition for prolonged periods may sustain this damage:
   a. cracked case
   b. corroded cell connectors
   c. sulfated plates

8. If a battery requires frequent additions of water, the most likely cause is:
   a. loose or corroded cables
   b. high voltage regulator setting
   c. cracked case

9. A 12-volt battery should normally use no more than ___ ounces of water per month.
   a. 8
   b. 4
   c. 2

10. To clean dirt and corrosion from a battery, use:
   a. 1/2 lb. of baking soda in 1 gal. of water
   b. kerosene
   c. plain water

11. If electrolyte drawn from a cell into the hydrometer is muddy in color, the most likely cause is:
    a. shedding of negative plates
    b. shedding of positive plates
    c. corrosion

12. On systems with negative ground, the negative cable should always be connected first.
    a. True
    b. False

13. When starting engine with booster battery, cables should be connected as follows:
    a. positive to negative and negative to positive
    b. positive to positive and negative to negative
    c. positive to positive- negative terminal of booster battery to engine block or other ground on disabled car

14. Installing cables incorrectly will reverse battery polarity and cause the following damage:
    a. ruined alternator rectifier diodes
    b. shorted battery cells
    c. burned out coil

15. The purpose of side terminals on batteries is to:
    a. save space
    b. strengthen the battery
    c. prevent build-up of corrosion

16. At the same charging rate, it will take about ____times as long to recharge a battery with a specific gravity reading of 1.110 as the same size of the battery with a reading of 1.220.
    a. 4
    b. 2
    c. 8

17. Hydrometer readings should be taken immediately after water has been added to the battery.
    a. True
    b. False

18. The maximum permissible difference in cell voltage between the highest and lowest cells is:
    a. .05
    b. .5
    c. 1

19. When boost-charging a dry-charge battery after activating it, specific gravity must reach at least 1.250, and electrolyte temperature must be 80 deg. or more.
    a. True
    b. False

20. When a car gets older and is used only for short trips, it is good economy to install a smaller battery than the original equipment.
    a. True
    b. False

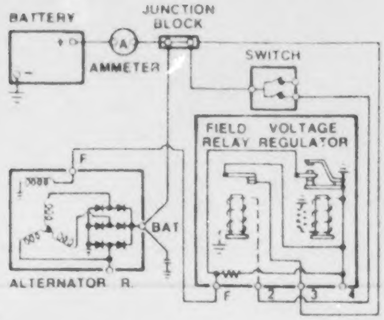
21. Battery cells will have more negative plates than positive plates
    a. True
    b. False

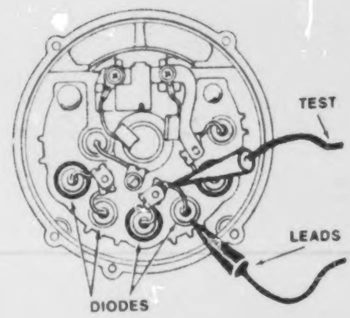
22. The specific gravity test cannot be performed on many new batteries.
    a. True
    b. False

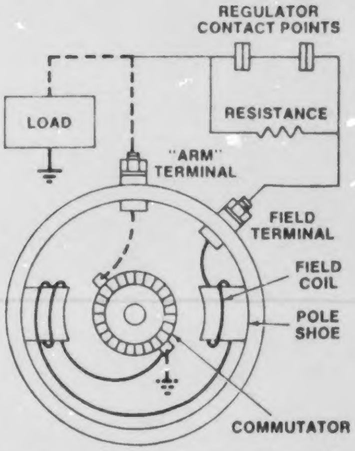
23. You should fast charge a battery with sulfated plates in order to get the sulfate off from the plates.
    a. True
    b. False

24. A teaspoon of baking soda in each cell will make the battery stronger.
    a. True
    b. False

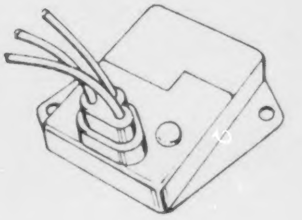
25. If a battery has ice in the cells, it should be thawed at room temperature before it is charged.
    a. True
    b. False

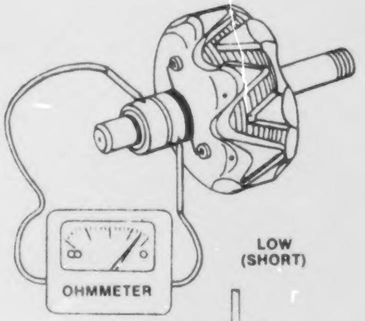

BATTERY
JUNCTION BLOCK
AMMETER
SWITCH
FIELD RELAY
VOLTAGE REGULATOR
F
BAT
ALTERNATOR
R
F
2
3
4

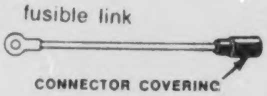

TEST
LEADS
DIODES

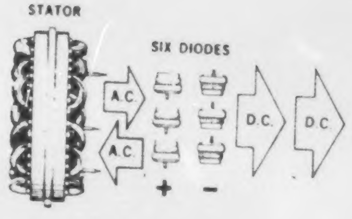

REGULATOR CONTACT POINTS
LOAD
RESISTANCE
"ARM" TERMINAL
FIELD TERMINAL
FIELD COIL
POLE SHOE
COMMUTATOR

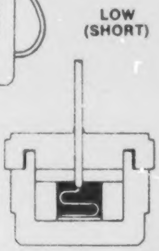
INTERNALLY GROUNDED TYPE—"B"

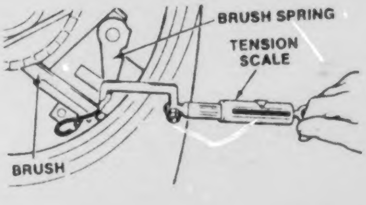




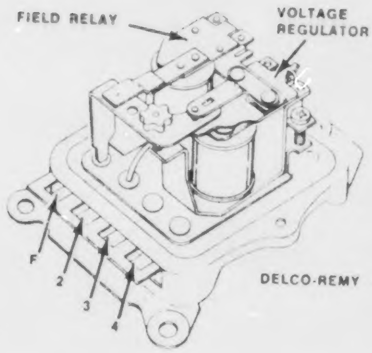

fusible link
CONNECTOR COVERING

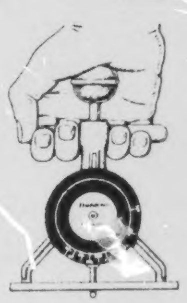

STATOR
SIX DIODES
A.C.
A.C.
D.C.
D.C.
+
−

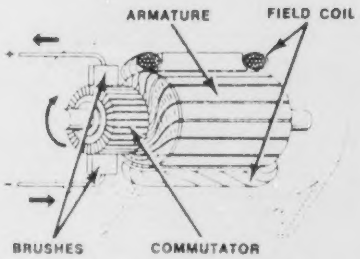


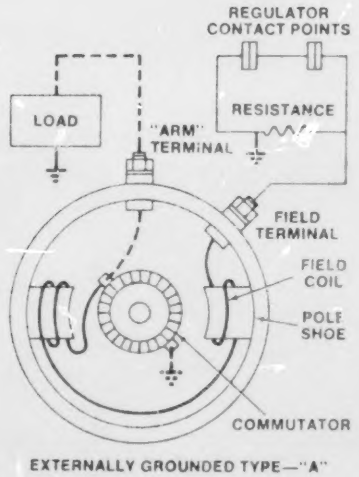

BRUSH SPRING
TENSION SCALE
BRUSH

The Charging System

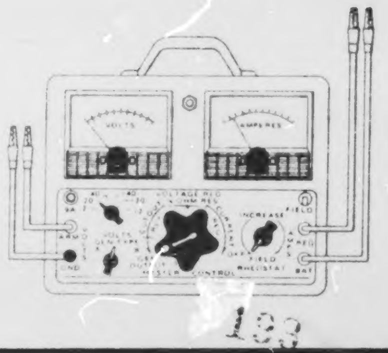

FIELD RELAY
VOLTAGE REGULATOR
F
2
3
4
DELCO-REMY

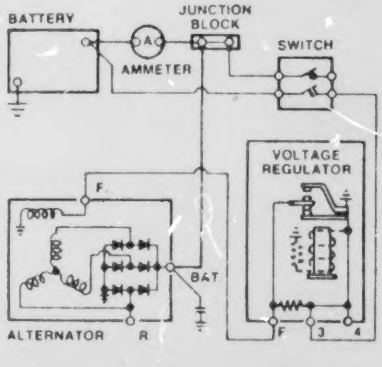



ARMATURE
FIELD COIL
BRUSHES
COMMUTATOR


REGULATOR CONTACT POINTS
LOAD
RESISTANCE
"ARM" TERMINAL
FIELD TERMINAL
FIELD COIL
POLE SHOE
COMMUTATOR

EXTERNALLY GROUNDED TYPE—"A"


VOLTS
AMPERES
INCREASE
FIELD
REG
BAT
GND
FIELD RHEOSTAT
CONTROL


BATTERY
JUNCTION BLOCK
AMMETER
SWITCH
VOLTAGE REGULATOR
F.
BAT
ALTERNATOR
R
F
3
4

REFERENCE

The texts chosen were selected because they are in current use by the instructors who compiled this manual. You should have a copy of at least one in your shop.

The text books are to be used as references for each exercise in this book. For each exercise you will find a number followed by page numbers. Look up the book number on this list and the page numbers will corresponds to the exercise you are working. For example if you find 5. 103-211 in the reference section you would check this reference list and find that book No. 5 is Auto Mechanics by H. E. Ellinger. In that book, pages 103-211 will apply to the exercise you are working.

	TEXT	AUTHOR	PUBLISHER
1.	Auto Service and Repair 1975	Stockel	Goodheart - Willcox
2.	Auto Mechanics Fundamentals 1974	Stockel	Goodheart - Willcox
3.	Motor Auto Engines and Electrical Systems 1975	Hearst Corporation	Motor
4.	Automotive Encyclopedia 1975	Tobotdt - Johnson	Goodheart - Willcox
5.	Auto Mechanics Second Edition	Ellinger	Prentice - Hall
6.	Automotive Mechanics	Crouse	McGraw - Hill
7.	The Auto Book	Crouse	McGraw - Hill
8.	Automotive Chassis And Accessory Circuits	Brezcha/Samuels	Prentice - Hall

Auto Mechanics
Charging System
No. C- Introduction

The charging system does two jobs, it recharges the battery and produces current during operation. If the charging system fails to recharge the battery and produce current during operation it will effect the whole electrical system.

In the service field there is a need for persons who can pinpoint a problem in the charging circuit. No more can a service man start replacing parts till the problem seems to be alleviated.

The information and worksheets on the charging system are designed to help you get an understanding of the operation of the system and to help you get some practical experience at charging system testing and servicing. Some of this practical experience involves you using the repair and service manuals. Learn how to use the repair and service manuals and you will eventually become proficient at pinpointing most charging system difficulties.

Auto Mechanic's
Charging System
No. C- Index

C- 1 -- Safety

C- 2 -- Alternator Component I. D.

C- 3 -- Regulator Component I. D.

C- 4 -- Generator Component I. D.

C- 5 -- Circuits - Symbols

C- 6 -- Generator Operation

C- 7 -- D C Regulator Operation

C- 8 -- Alternator Regulator Operation

C- 9 -- Alternator Operation

C-10 -- Alternator And Regulator Test On Vehicle

C-11 -- Alternator Bench Test

C-12 -- Generator And Regulator Tests On Vehicle

C-13 -- Generator Bench Test

C-14 -- Diode Removal And Installation

C-15 -- Changing Pulley

C-16 -- Bearing R & R

C-17 -- Brush Replacement

C-18 -- Reface Generator Commutator

C-19 -- R & R Alternator

C-20 -- R & R Regulator

C-21 -- R & R Drive Belt

C -- Final Test - Charging System

SCHOOL ____________________ STUDENT ____________________

INSTRUCTOR ____________________ YEAR GRAD ____________________

AUTOMOTIVE ELECTRICAL COMPETENCIES-CHARGING SYSTEM

	COMPETENCY	JR	M	C	SR	M	C	VOC	M	C	IND	M	C
C-1	Safety												
C-2	Alternator Component I. D												
C-3	Regulator Component I. D												
C-4	Generator Component I. D.												
C-5	Circuits - Symbols												
C-6	Generator Operation												
C-7	D C Regulator Operation												
C-8	Alternator Regulator Operation												
C-9	Alternator Operation												
C-10	Alternator and Regulator Tests on Vehicle												
C-11	Alternator Bench Test												
C-12	Generator and Regulator Tests on Vehicle												
C-13	Generator Bench Test												
C-14	Diode Removal And Installation												
C-15	Changing Pulley												
C-16	Bearing R & R												
C-17	Brush Replacement												
C-18	Reface Generator Commutator												
C-19	R & R Alternator												
C-20	R & R Regulator												
C-21	R & R Drive Belt												

THIS COMPETENCY SHEET LISTS ALL THE SKILLS REQUIRED FOR THIS BOOK. THEY ARE LISTED IN A LOGICAL ORDER ALTHOUGH THERE IS NO FIXED SEQUENCE FOR COMPLETING THE EXERCISES. EACH HEADING HAS A COLUMN TO ITS RIGHT WITH SPACES TO ALLOW GRADING AFTER YOU COMPLETE THAT EXERCISE. WE HAVE TAKEN INTO ACCOUNT THAT NOT EVERY EXERCISE WILL BE COMPLETED THE FIRST YEAR. THEREFORE, WE HAVE SPOTS FOR JUNIOR, SENIOR, VOCATIONAL AND INDUSTRY. AS YOU COMPLETE A PARTICULAR COMPETENCY, (OR TASK) YOU WILL BE GRADED ACCORDING TO THE SCALE AT THE BOTTOM OF THIS SHEET. ALSO, IF THERE ARE ANY MATH OR COMMUNICATION SKILLS REQUIRED THEY CAN ALSO BE GRADED USING THE CODE N, 1, 2, OR 3. THE DATE OF COMPLETION WILL BE ENTERED UNDER THE APPROPRIATE YEAR AND COMPETENCY. YOU WILL HAVE THE OPPORTUNITY TO UPGRADE ANY ONE OF THESE SKILLS AT ANY TIME AFTER YOU FIRST COMPLETE THE TASK AND HAVE THE NEW RATING ENTERED ON THIS SHEET.

RATING SCALE

N = No opportunity to perform
1 = Completed exercise with close supervision
2 = Completed exercise with little supervision
3 = Completed exercise without supervision

M = Math
C = Communications

SCHOOL________________________ STUDENT________________________

INSTRUCTOR________________________ YEAR GRAD________________________

AUTOMOTIVE ELECTRICAL COMPETENCIES-CHARGING SYSTEM

	COMPETENCY	JR	M	C	SR	M	C	VOC	M	C	IND	M	C
C-1	Safety												
C-2	Alternator Component I. D												
C-3	Regulator Component I. D												
C-4	Generator Component I. D.												
C-5	Circuits - Symbols												
C-6	Generator Operation												
C-7	D C Regulator Operation												
C-8	Alternator Regulator Operation												
C-9	Alternator Operation												
C-10	Alternator and Regulator Tests on Vehicle												
C[illegible]	Alternator Bench Test												
C-12	Generator and Regulator Tests on Vehicle												
C-13	Generator Bench Test												
C-14	Diode Removal And Installation												
C-15	Changing Pulley												
C-16	Bearing R & R												
C-17	Brush Replacement												
C-18	Reface Generator Commutator												
C-19	R & R Alternator												
C-20	R & R Regulator												
C-21	R & R Drive Belt												

RATING SCALE

N = No opportunity to perform
1 = Completed exercise with close supervision
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3 = Completed exercise without supervision

M = Math
C = Communications

AUTO MECHANICS

Electrical Competencies - Charging System

No. C-1 Safety

OBJECTIVE: After you have completed this exercise you will be able to safely work on automotive charging systems.

EXPLANATION: It is the intention of this unit to instill safe working procedures for the protection of personel and equipment used in changing system servicing.

MATERIALS NEEDED:

TOOLS NEEDED:

References	Do
#1. Ch.22-22	1. Study reference assignment
#2. --	2. Read safety sheet
#3. --	3. Quiz - 100%
#4. p. 355	4. Check with instructor
#5. --	
#6. Ch. 31-290	
#7. --	
#8. --	

Electrical Competencies - Charging System

No. C-1 Safety

Information Sheet # 1

1. Always disconnect the battery ground cable before making test connections and before disconnecting test connections, because of the possibility of damage to the electrical system.

2. Turn all lights and accessories to the OFF position before making any tests, unless instructed to do otherwise.

3. Be sure of battery polarity before installing a battery. Reverse polarity will ruin the diode rectifiers in most AC systems.

4. When using a booster battery to start an engine, connect it in parallel within the battery to be boosted (+ to + and - to -.)

5. Do not use a fast charger in AC charging systems without first disconnecting battery cable.

6. Disconnect the field wire in AC systems if a battery charger is to be used to start the engine.

7. Do not short across or ground any terminals or connections on the alternator,regulator, or generator regulator unless instructed to do so.

8. Never ground the output, battery, or field terminals on an alternator.

9. Never ground the field circuit between the alternator and regulator unless instructed to do so.

10. Never adjust regulators until operating temperature has been reached.

11. Turn ignition switch to the OFF position when removing or installing the regulator cover.

12. Use insulated tools when adjusting the regulator.

13. Never try to polarize an alternator.

14. Always follow manufacture or test instrument checkout procedures.

15. NEVER OPERATE AN ALTERNATOR ON AN OPEN CIRCUIT. THIS WILL CREATE HIGH VOLTAGE AND COULD BE DANGEROUS TO ANYONE TOUCHING BATTERY TERMINAL, ON THE ALTERNATOR AND BURN OUT DIODES.

Electrical Competencies - Charging System
No. C-1 Safety

Worksheet # 1

Name ________________________ Date __________ Grade __________

T.F. 1. Alternators must be polarized.

T.F. 2. Battery connections need not be removed to R & R an alternator.

T.F. 3. Diodes can be ruined by installing a battery with incorrect polarity.

T.F. 4. Alternators should not be operated without a load.

T.F. 5. When boost starting, positive is connected to negative and negative to positive.

T.F. 6. It is important to disconnect the battery ground cable when fast charging a battery on an AC system.

T.F. 7. When using a battery charger for boost starting it is important to remove the F wire.

T.F. 8. Temperature is not important when making voltage regulator adjustments.

T.F. 9. Never ground the output, battery, or field terminals on an alternator.

T.F. 10. It is always very important to follow manufacture or test equipment checkout procedures when diagnosing a generating system problem.

Instructor's Initials __________

AUTO MECHANICS

Electrical Competencies - Charging System

No. C-2 Alternator Component I. D.

OBJECTIVE: After competion of this exercise you will be able to identify all the components of the alternator.

EXPLANATION: Knowing the names of the parts that make up an alternator will help you in repair of alternators.

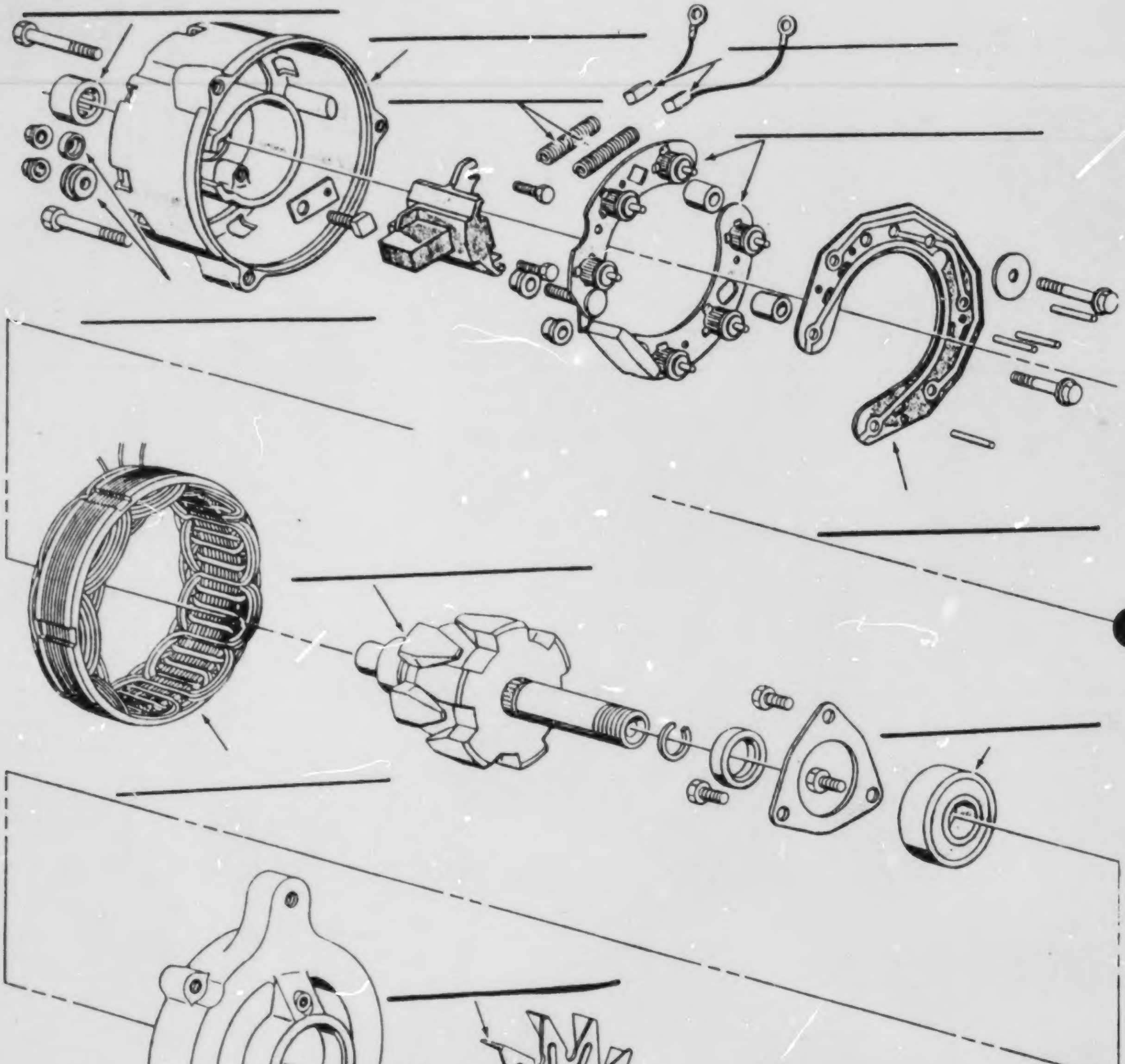
MATERIALS NEEDED:

TOOLS NEEDED:

References	Do
#1. Ch. 22- (26-27)	1. Study reference assignment
#2. Ch. 19- (364)	2. Complete written worksheet
#3. --	3. Check with instructor.
#4. p.356	
#5. p. 175 & p. 188	
#6. p. 295	
#7. p. 249	
#8. --	

Electrical Competencies - Charging System
No. C-2 Alternator Component I.D.
Name ____________________ Date _________ Grade ________ Worksheet # 1

VISUAL IDENTIFICATION OF AN AUTOLITE ALTERNATOR



Alternator Assembly (exploded view)

Instructor's Initials __________

AUTO MECHANICS

Electrical Competencies - Charging System

No. C -3 - Regulator Component I. D.

OBJECTIVE: After completion of this exercise you will be able to identify components of regulators.

EXPLANATION: It is important to be able to identify the components of a regulator so we can adjust and/or receive the correct replacement regulator.

MATERIALS NEEDED:

TOOLS NEEDED:

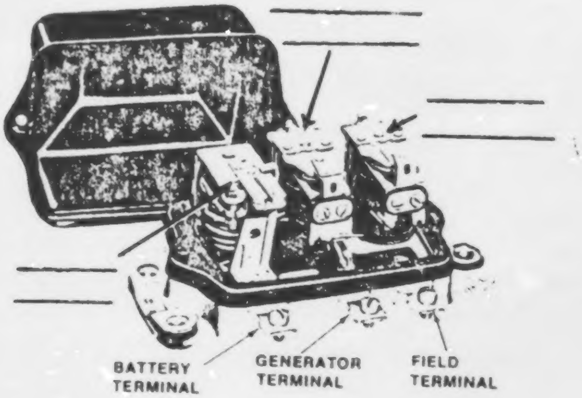
References	Do
#1. Ch.22 -29 & 40	1. Study reference assignment
#2. p. 384 & p. 390	2. Complete written worksheet
#3. p. 557 & p. 593	3. Check with instructor
#4. p. 363 & p. 369	
#5. p. 291	
#6. p. 283 & p. 288	
#7. p. 246 & p. 254	

Electrical Competencies - Charging System

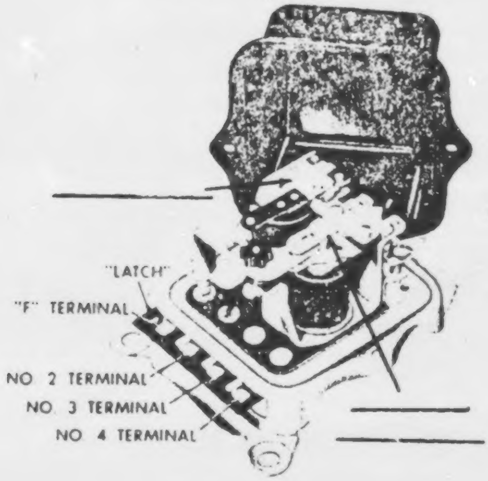
No. C -3 Regulator Component I. D. Worksheet # 1

Name Date Grade

DIRECTIONS: From assigned reference material, fill in the correct name on lines provided.


BATTERY TERMINAL
GENERATOR TERMINAL
FIELD TERMINAL

Current and voltage regulator for a dc generator, with the cover removed.


"LATCH"
"F" TERMINAL
NO. 2 TERMINAL
NO. 3 TERMINAL
NO. 4 TERMINAL

Voltage regulator. The field relay is used only on vehicles having a charge indicator light instead of an ammeter

Instructor's Initials

AUTO MECHANICS

Electrical Competencies- Charging System

No. C-4 Generator Component I.D.

OBJECTIVE: After the completion of this exercise you will be able to identify the major components of the automotive generator.

EXPLANATION: This unit shows the location and name of the automotive generator components.

MATERIALS NEEDED:

TOOLS NEEDED:

References	Do
#1.p.22-14 -22-15	1. Study references assigned
#2.p.379	2. Study information sheet
#3.p.544-545	3. Complete worksheet
#4.p345	4. Check with instructor
#5.p.176	
#6.p.281	
#7.p. 242-243	

Generators

In the early days of the gasoline automobile there were not many electrical devics and the generator had only a small capacity. As additional electrical equipment was added it was necessary to increase the capacity of the generator to take care of the increased load. While the battery capacity of the 6-volt electrical system has increased only slightly to take care of the starting and parking light load, the 6-volt generator capacity has increased from approximately 15 amperes on early engines to upwards of 50 amperes at which period 12-volt generators came into use.

Although of approximately the same physical size as the 6-volt units, 12-volt generators provide about one-fourth more electrical output to carry the entire electrical system load. This is possible because finer wires can be used to carry 12-volt currents;more armature conductors can be put into the same space; more powerful field coils, wound with more turns of finer wire, can be placed in the same size frame as used for the 6-volt generator.

Generator Construction

The generator is mounted on the front of the engine, Fig. 1, and is driven by the belt which also rotates the fan and water pump.

The principal parts of a generator, Fig. 2, are its circular field frame, field poles,armature and end plates or frames.

Automobile generators invariably have two field poles and two brushes. Larger generators for trucks and busses may have four or six field poles and an equal number of brushes.

Fig. 3 shows the generator circuit in its simplest form. The current produced in the armature is delivered to the brushes. Most of this current is sent to the external circuit (battery, lights, etc.) by way of the armature terminal. A small percentage is diverted (shunted) to the field coils to produce the magnetism in the field poles. Arrows show the paths through which the current flows.

The generator in Fig. 3 makes no provision for regulation of current and voltage. In order to install a regulator, and insulated field terminal must be added, Fig.4 and 5, whereas in Fig. 3 the field winding is grounded. The generator regulator may be connected between the armature terminal and field terminal, Fig. 4, or it may be connected between the field terminal and ground, Fig.5. In Fig.4 and 5,the regulator is represented by a resistance in parallel with the points. Actually there may be two of these units in the regulator.

The regulators indicated in Fig. 4 and 5 control both voltage and current. They are called three-unit regulators because there is a unit for (1) voltage, (2) current, (3) a device for breaking the current to the battery when the engine is stopped, called a reverse current cutout relay, or circuit breaker.

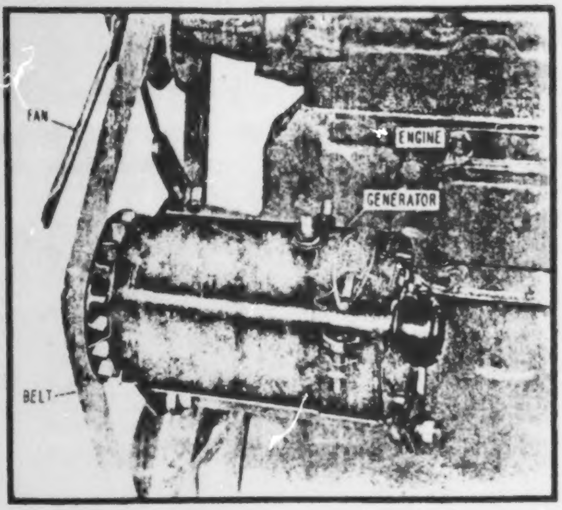

FAN
ENGINE
GENERATOR
BELT

Fig. 1 *Typical automobile generator driven by fan belt*

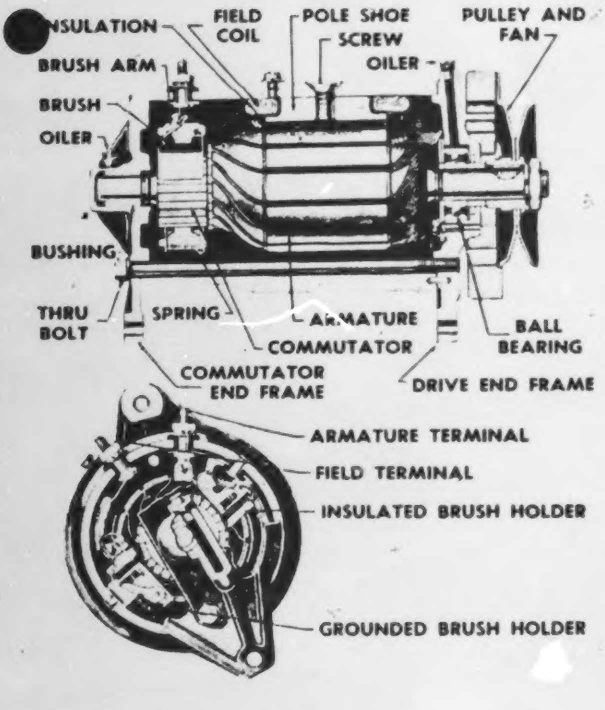

INSULATION
FIELD COIL
POLE SHOE
SCREW
PULLEY AND FAN
BRUSH ARM
OILER
BRUSH
OILER
BUSHING
THRU BOLT
SPRING
ARMATURE
COMMUTATOR
BALL BEARING
COMMUTATOR END FRAME
DRIVE END FRAME
ARMATURE TERMINAL
FIELD TERMINAL
INSULATED BRUSH HOLDER
GROUNDED BRUSH HOLDER

Fig. 2 *Sectional view of generator*

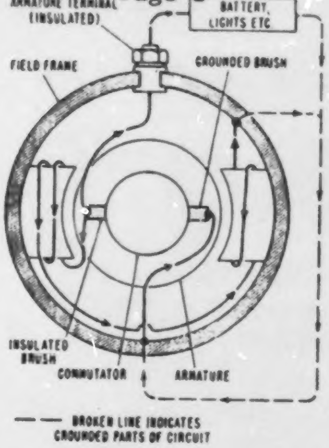

ARMATURE TERMINAL (INSULATED)
BATTERY, LIGHTS ETC
FIELD FRAME
GROUNDED BRUSH
INSULATED BRUSH
COMMUTATOR
ARMATURE
BROKEN LINE INDICATES GROUNDED PARTS OF CIRCUIT

Fig. 3 *Simple diagram of current flow in a shunt generator*

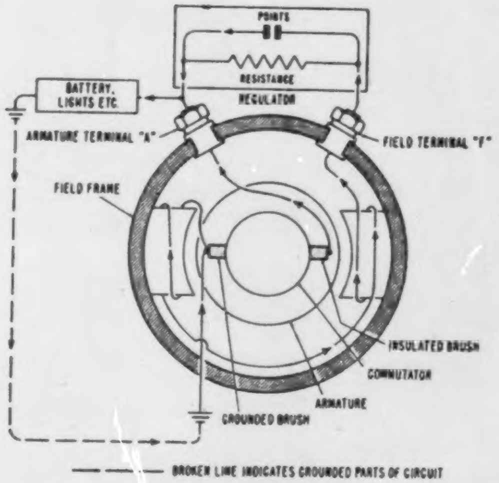

POINTS
RESISTANCE
REGULATOR
BATTERY, LIGHTS ETC
ARMATURE TERMINAL "A"
FIELD TERMINAL "F"
FIELD FRAME
INSULATED BRUSH
COMMUTATOR
ARMATURE
GROUNDED BRUSH
BROKEN LINE INDICATES GROUNDED PARTS OF CIRCUIT

Fig. 4 *Regulator connected between armature and field terminals*

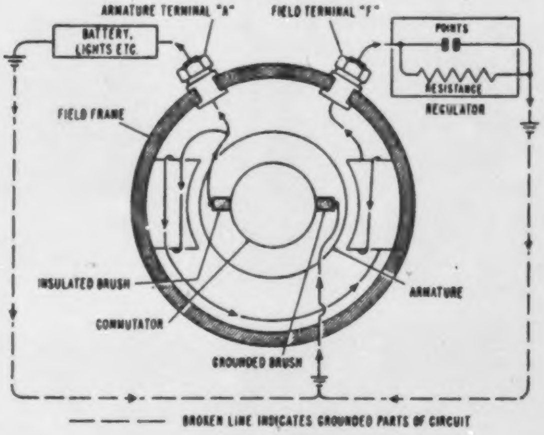

ARMATURE TERMINAL "A"
FIELD TERMINAL "F"
BATTERY, LIGHTS ETC.
POINTS
RESISTANCE
REGULATOR
FIELD FRAME
INSULATED BRUSH
ARMATURE
COMMUTATOR
GROUNDED BRUSH
BROKEN LINE INDICATES GROUNDED PARTS OF CIRCUIT

Fig. 5 *Regulator connected between field terminal and ground*

A sectional view of typical generator is shown in Fig. 2. The field frame is a cylindrical steel tube. The commutator end frame and the drive end frame are attached to the two ends of the tubular field frame. Two long through bolts hold the two end frames in place. The bolts are threaded into holes in the drive end frame and are kept tight by lock washers under the heads of the bolts at the communtator end. The two end frames are "located" by dowels. The field poles,or pole shoes as they are often called, are each held in place by a husky pole shoe screw.

The armature shaft is mounted in a ball bearing at the drive end and in a bushing at the commutator end. A ball bearing is always used at the drive end because of the load imposed by the pull of the fan belt.

Automobile generators are equipped with a cooling fan which is attached to the drive pulley. This fan, Fig. 6, is a centrifugal design whose blades throw air outward. The consequent suction at the fan hub draws air through the generator as shown and cools the armature and therefore increases the amperage the generator can be made to produce. The explanation is simple. The greater the armature amperage the more the copper armature windings are heated by the flow of current. If armature amperage exceeds a certain value, the increase in temperature will destroy the insulation. The cooling effect of the air helps keep the temperature down. Therefore, an air-cooled armature can carry more amperes that an uncooled one without danger of damaging the insulation.

The drive pulley is keyed to the armature shaft and is held in place by a nut and lock washer.

The armature windings are contained in slots in the armature core, Fig. 7. The core is not a solid piece of iron mounted on the armature shaft. Instead it consists of numerous slotted discs of iron or soft steel assembled on the armature shaft. The discs are insulated from each other by special varnish or thin paper. This "laminated"armature core is neccessary to avoid the production to stray currents in the armature core. Bear in mind that the rotating core acts like a conductor. Stray voltages and current are produced in it. If the core were one piece,the currents produced in the core would seriously reduce the amount of current produced in the armature windings. The problem is solved by breaking the core up into many thin laminations which are insulated from each other- the net result being that the stray currents are negligible in value.

Each armature coil,Fig. 7 consists of several turns of wire which fit into two diametrically opposite slots in the armature core. All the coils, of course, are connected in series. The ends of each armature coil are soldered in place, Fig. 7. The copper commutator bars are insulated from each other by sheet mica.

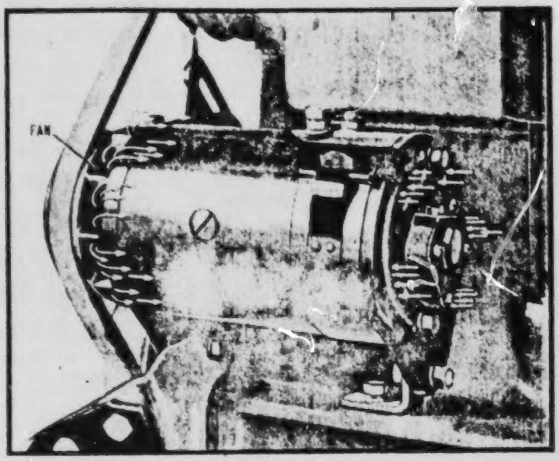


Fig. 6 The centrifugal fan pulls air through the generator as shown by the arrows, thus cooling the armature

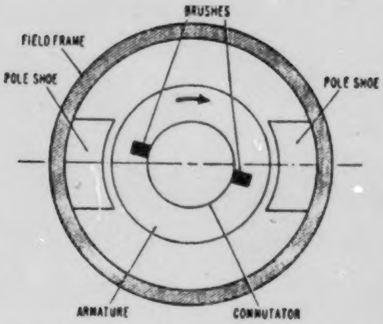

BRUSHES
FIELD FRAME
POLE SHOE
POLE SHOE
ARMATURE
COMMUTATOR

Fig. 8 Because of distortion of the magnetic field the brushes are tilted with respect to the center line of the field poles

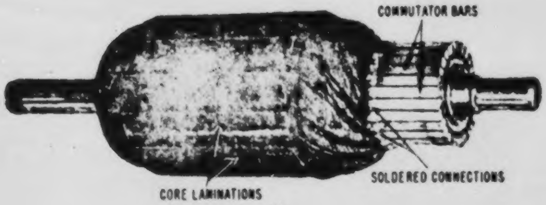

COMMUTATOR BARS
SOLDERED CONNECTIONS
CORE LAMINATIONS

Fig. 7 The ends of each armature coil are located to diametrically opposite armature slots

Brushes

In Fig.3 the brushes are located in line with the centers of the pole pieces on the assumption that the armature coil being commutated is not cutting any magnetic lines of force. The coil commutated is the one whose commutator bars are in contact with the brushes. This brush position is okay when the current is the armature is small with the result that the magnetic field created by the armature is too weak to distort the magnetic field of the pole shoes.

But actual armature currents of 20 to 40 amperes or more distort the magnetic field of the pole pieces, moving the field a few degrees in the direction of armature rotation. Therefore, since the armature coils which are being commutated must not cut any lines of force, it is necessary to relocate the brushes the same number of degrees in the direction of rotation, Fig. 8, rather than have them in the central position indicated in Fig. 3.

There are two methods of mounting brushes: (1) The brush is attached to a pivoted (swiveled) arm, Figs.9,10. (2) The brush is mounted in a box-like structure with open ends,Fig.11,12. If the commutator rotates away from the brush it is called a trailing type, Fig. 9,11, whereas if the commutator rotates toward the brush,Fig.10,12,it is called a reaction type.

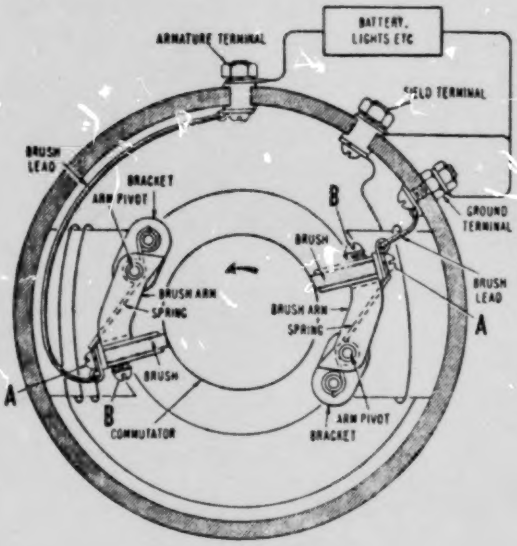

ARMATURE TERMINAL
BATTERY, LIGHTS ETC
FIELD TERMINAL
BRUSH LEAD
BRACKET
ARM PIVOT
B
BRUSH
GROUND TERMINAL
BRUSH ARM
SPRING
BRUSH ARM
SPRING
BRUSH LEAD
A
A
BRUSH
B
COMMUTATOR
ARM PIVOT
BRACKET

Fig. 9 Trailing swivel type brush holder. The brush arm is pivoted to the bracket. The brush is attached to the bracket by screw A. The spring holds the brush against the commutator. The brush lead is attached by screw B

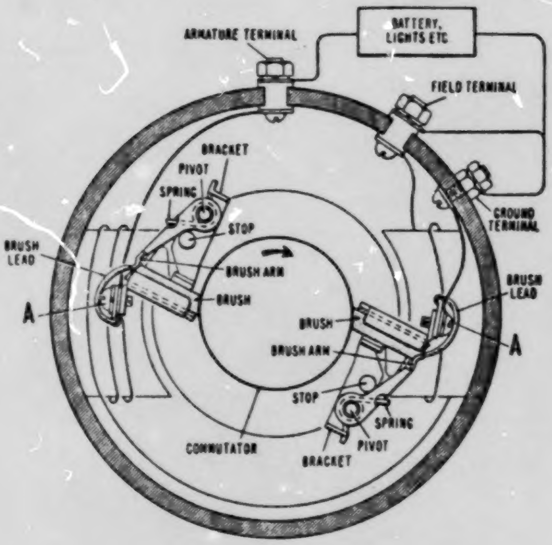

ARMATURE TERMINAL
BATTERY, LIGHTS ETC
FIELD TERMINAL
BRACKET
PIVOT
SPRING
STOP
GROUND TERMINAL
BRUSH LEAD
BRUSH ARM
BRUSH
A
BRUSH LEAD
BRUSH
BRUSH ARM
A
STOP
SPRING
PIVOT
COMMUTATOR
BRACKET

Fig. 10 Reaction swivel type brush holder. The brush arm is inserted in a holder in end of brush arm. The spring causes the arm to press the brush against the commutator. The brush lead is attached by screw A

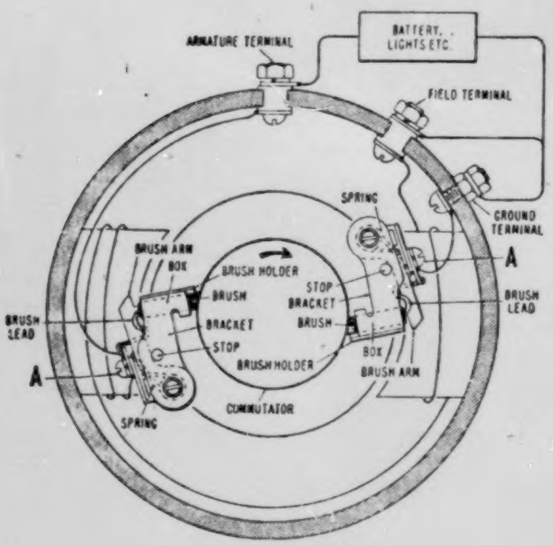

ARMATURE TERMINAL
BATTERY, LIGHTS ETC.
FIELD TERMINAL
SPRING
GROUND TERMINAL
BRUSH ARM
BOX
BRUSH HOLDER
A
BRUSH
STOP
BRACKET
BRUSH LEAD
BRUSH LEAD
BRACKET
BRUSH
STOP
BOX
BRUSH HOLDER
BRUSH ARM
A
COMMUTATOR
SPRING

Fig. 11 Trailing box type brush holder. The right end of the bracket is formed into a box in which the brush can slide freely. The spring presses the brush arm against the brush and holds the brush against the commutator. The brush lead is attached to screw A

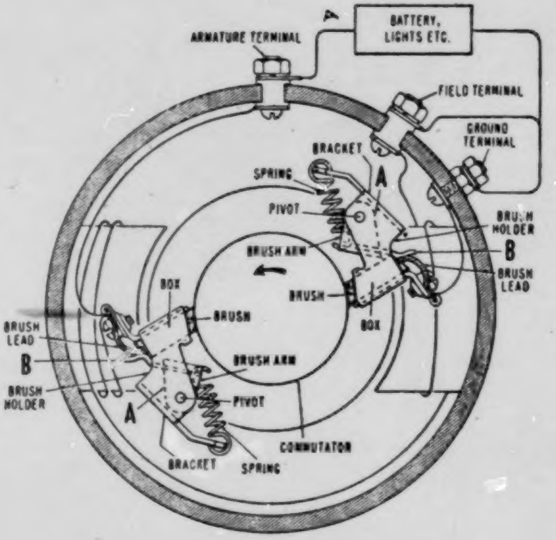
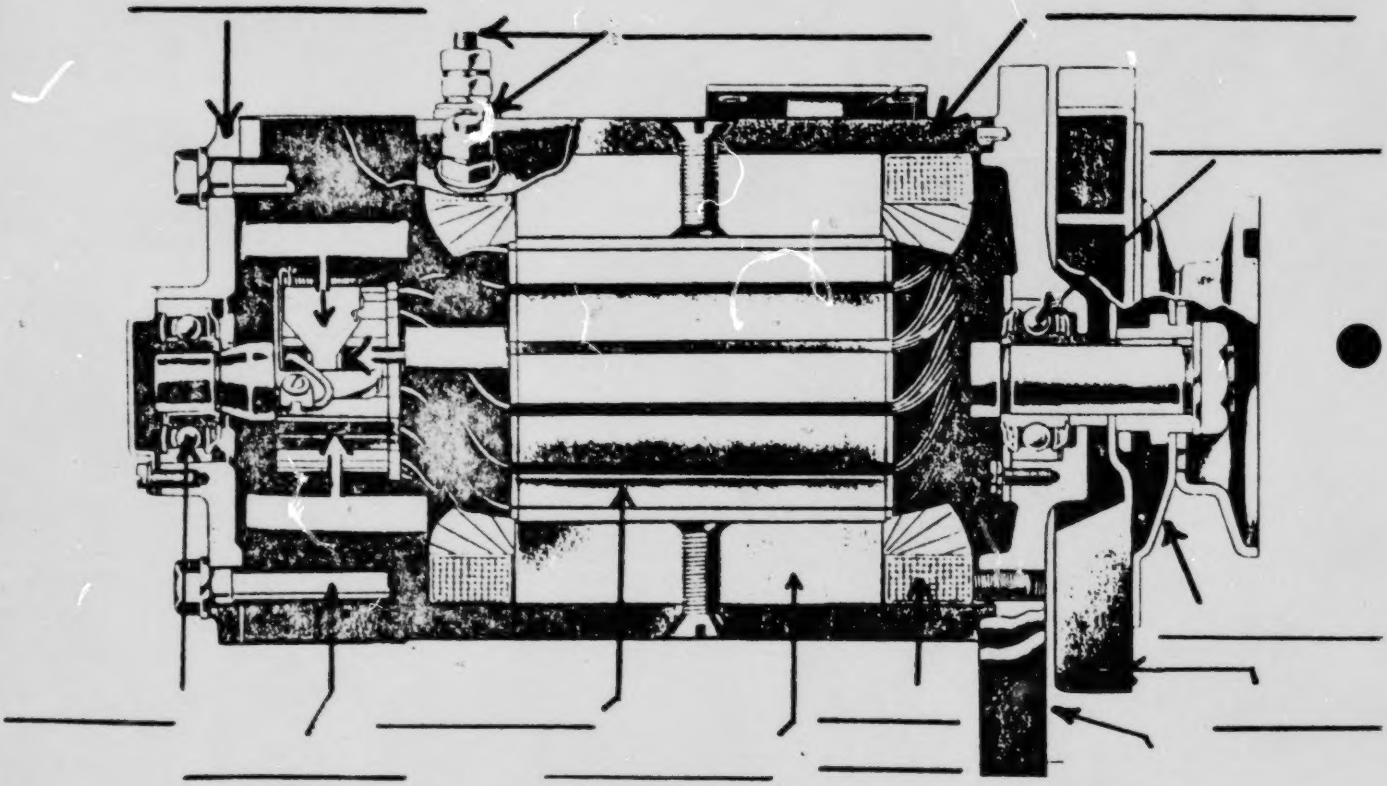

ARMATURE TERMINAL
BATTERY, LIGHTS ETC.
FIELD TERMINAL
GROUND TERMINAL
BRACKET
SPRING
A
PIVOT
BRUSH HOLDER
BRUSH ARM
B
BRUSH LEAD
BOX
BRUSH
BRUSH
BOX
BRUSH LEAD
B
BRUSH ARM
BRUSH HOLDER
PIVOT
A
COMMUTATOR
BRACKET
SPRING

Fig. 12 Reaction box type brush holder. The brush is mounted in a box at right of bracket. The brush can slide freely in the box. The brush is forced against the commutator by part B which is firmly attached to part A which is mounted on a pivot. The spring pulls on part A, causing part B to press against the brush

Electrical Competencies - Charging System

No. C -4 Generator Component I. D. Worksheet # 1

DIRECTIONS: From the assigned reference material, fill in the correct name on the lines provided.



Side view of typical direct-current generator found on older engines.

Instructor's Initials ___________

AUTO MECHANICS

Electrical Competencies - Charging System

No. C-5 Circuits-Symbols

OBJECTIVE:

After the completion of this exercise you will be able to identify the components of a alternator and regulator on a written wiring diagram.

EXPLANATION:

You will need to know the symbols which represent the parts of an alternating charging system to aid in your understanding of that system. Knowing the symbols will also aid in diagnostic work using such diagrams in the future.

MATERIALS NEEDED:

TOOLS NEEDED:

References	Do
#1. --	#1. Study references assigned
#2. P. 389	#2. Complete worksheet
#3. p. 592-593	#3. Check with instructor
#4. p. 369-370	
#5. p. 174-182	
#6. p. 285	
#7. p. 252-254	
AUTOMOTIVE EMISSION CONTROL AND TUNE-UP PROCEDURES IMI 1972 p. 170 IMI 1975 p. 178	

Electrical Competencies - Charging System

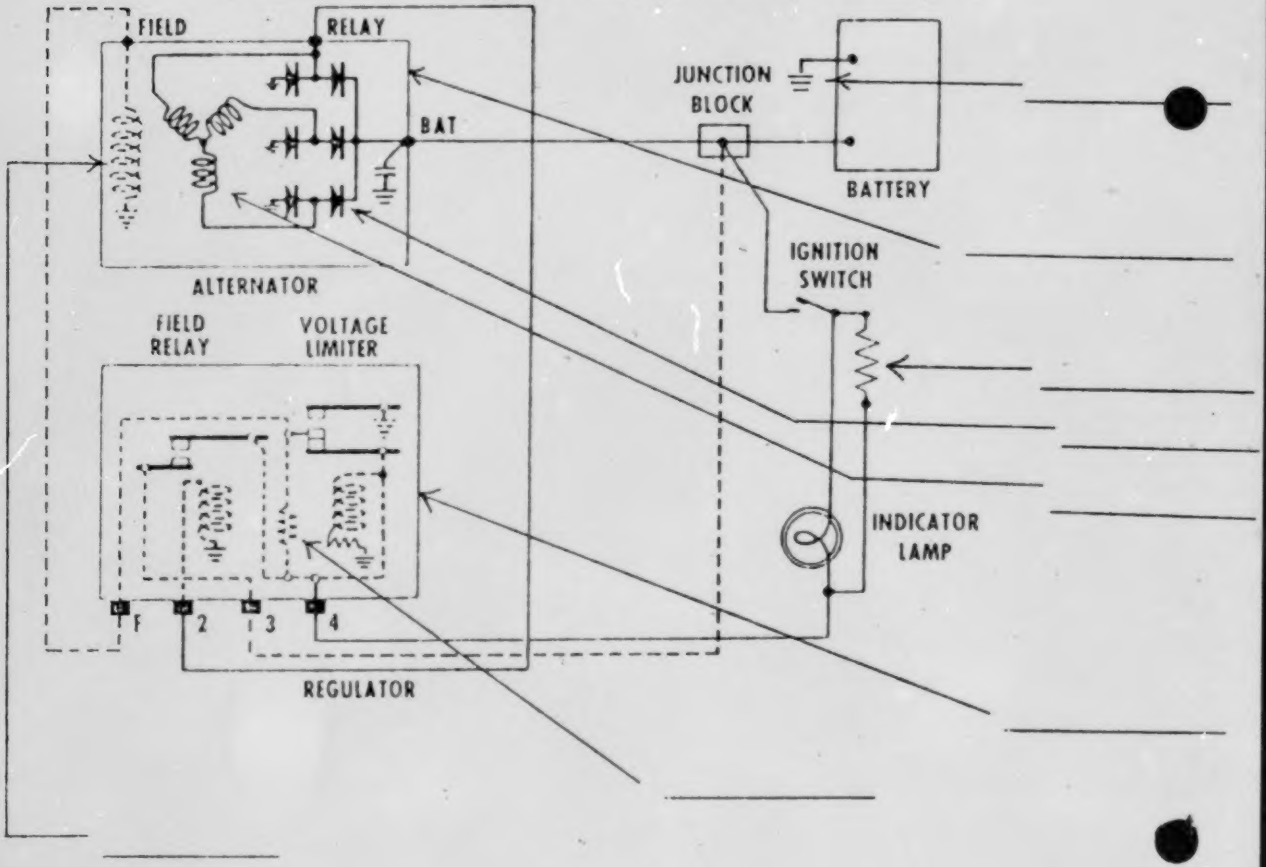
No. C - 5 Circuits - Symbols

Work sheet # 1

Name ________________________________ Date ______________ Grade _________

DIRECTIONS: Refer to assigned readings and from the readings and diagrams fill in the names of the indicated items on the line provided.

Indicator lamp without lamp relay


FIELD
RELAY
JUNCTION BLOCK
BAT
BATTERY
ALTERNATOR
IGNITION SWITCH
FIELD RELAY
VOLTAGE LIMITER
INDICATOR LAMP
F
2
3
4
REGULATOR

Instructor's Initials ________

AUTO MECHANICS

Electrical Competencies

No. C-6 Generator Theory of Operation

OBJECTIVE: After you have completed this exercise you should be familiar with the theory of electrical generation.

EXPLANATION: Knowing the theory of electrical generation will greatly assist you in the diagnosis of generator malfunctions.

MATERIALS NEEDED:

TOOLS NEEDED:

References	Do
#1. --	1. Study reference assignment
#2. P. 376-378	2. Study information Sheet
#3. p. 434-439	3. Complete written worksheet
#4. p. 346-347	4. Check with instructor
#5. p. 174-176	
#6. p.280-282	
#7. p. 241-245	
#8. --	

No. C-6 D C Generator Operation

Information Sheet # 1

Generator Theory of Operation

Electric current is a flow, or movement, of electrons. We can make electrons move by moving a wire through a magnetic field, as shown in Fig. 1. (The dot in the end of the conductor means that the current is moving toward you. If it were moving away from you, there would be a cross in the conductor.) When the conductor is moved through the magnetic field, it cuts through the magnetic limes of force. This cutting of the lines of force causes electrons to move. That is, it produces a flow of electric current. The dc generator works on this principle; it moves a conductor through a magnetic field. In the generator, movement of conductors is rotary movement. The conductors move in a circle inside the generator.

The generator has two major parts, the armature and the field-from assembly (Fig 2.). These parts resemble the armature and field frame assembly in the starting motor. The main difference is that, in the generator, the conductors in the armature and field coils are much smaller. The generator is mounted on the side of the engine. It is driven by a belt from a pulley on the engine crankshaft. As the armature is rotated, the armature conductors are carried through a magnetic field. Current is thus induced in them. The magnetic field comes from two field coils mounted on the inside of the field frame.

Figure 3 shows a dc generator in very simplified form. The armature is shown as a single loop of wire. The two field coils are shown as single turns of wire. The two pole shoes, around which the field coils are assembled, have some magnetism. When the armature starts to rotate, the wire loop cuts through the magnetic field. That action induces some current in the wire. The current flows out through one segment of the commutator. There, it splits. Some of the current goes through the two field coils and back to the other segment of the commutator. Most of the current goes to the "load" (an electric light or other electrical device). It passes through the load and then goes back to the other segment of the commutator. In this way, the current from the armature loop flows in two complete circuits.

The current flowing in the field coils increases the magnetism. The increased magnetism increases the amount of current induced in the armature loop. This is how large amounts of current are obtained from the generator. Many loops are added to the armature; they all work together to produce current.

Study Fig. 3 for a moment. Notice that, as the loop rotates, the two sides cut the magnetic field. They cut it first in one direction and then in the other. Thus the current flows through the loop first one way and then the other. The current alternates.

The commutator turns the alternating current into direct current. Notice, in Fig. 3 that the commutator which has two segments in the simple example, also rotates. The side of the loop that moves down through the magnetic field is always connected through its segments of the commutator to the right-hand brush. So every time the current reverses in the loop, the commutator segments also reverse positions. The current always flows out of the same brush and always flows back through the other brush.

In this way, the commutator and the brushes turn the ac of the armature loops into dc.

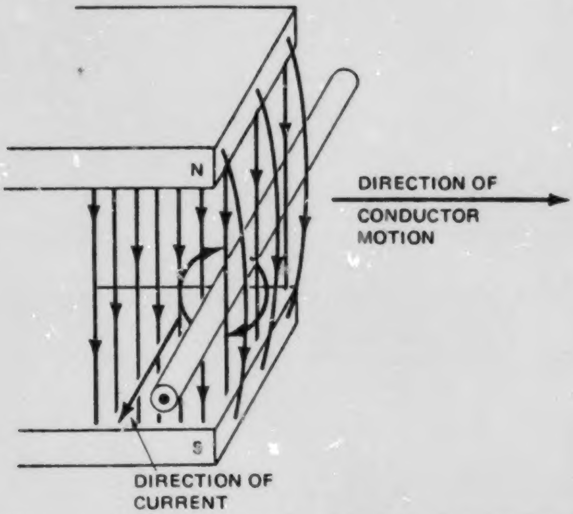

N
DIRECTION OF
CONDUCTOR
MOTION
S
DIRECTION OF
CURRENT

Fig. 1 A conductor, moving through a magnetic field as shown, has a flow of current induced in it.

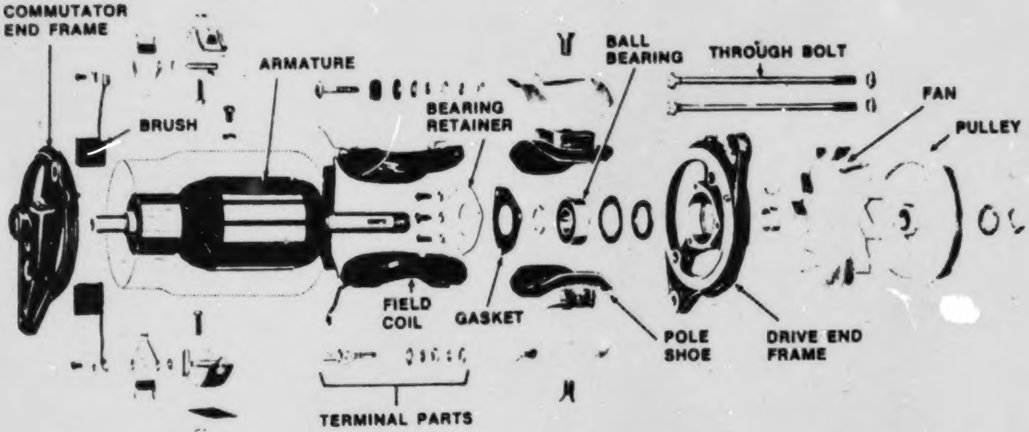

COMMUTATOR
END FRAME
ARMATURE
BRUSH
BEARING
RETAINER
BALL
BEARING
THROUGH BOLT
FAN
PULLEY
FIELD
COIL
GASKET
POLE
SHOE
DRIVE END
FRAME
TERMINAL PARTS

Fig. 2 Disassembled view of a passenger-car dc generator. (*Delco-Remy Division of General Motors Corporation*)

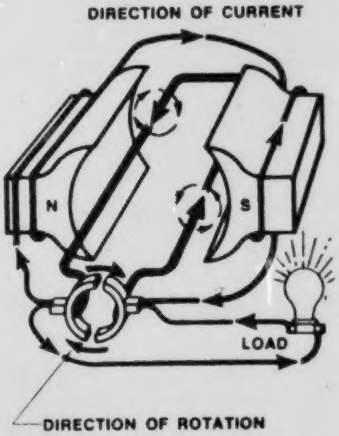

DIRECTION OF CURRENT
N
S
LOAD
DIRECTION OF ROTATION

Fig. 3 Simplified schematic diagram of a generator. The heavy arrows show the direction of current flow. The light circular arrows show the direction of magnetic fields around the conductors.

Electrical Competencies - Generating Systems

No. C-6 Generator Operation

Worksheet # 1

Name ______________________________ Date __________ Grade __________

1. ____________________, ____________________, and ____________________ are needed to produce electrical current.
2. The conductors in a generator are located in the ____________________.
3. The lines of magnetic force (flux) are produced by the ____________________.
4. The ____________________ are what covert the A C current to D C current in the generator.
5. The amount of ____________________ current controls the output of the generator.

AUTO MECHANICS

Electrical Competencies - Charging System

No. C-7 D C Regulator Operation

OBJECTIVE: After the completion of this exercise you will be able to complete wiring diagram of a D C regulator.

EXPLANATION: Knowing the operation of a mechanical regulator will help you trouble shoot the charging system.

MATERIALS NEEDED: Pencil

TOOLS NEEDED:

References	Do
#1. --	1. Study references assigned.
#2. p. 381-384	2. Study information sheets
#3. p. 556-564	3. Complete worksheet # 1 and # 2
#4. p. 363-368	4. Check With instructor.
#5. p. 192-194	
#6. p.282	
#7. p. 245-247	
#8. --	

Electrical Competencies - Generating Systems

No. C 7 D C Regulator Operation

Information Sheet # 1
Page 1

Purpose of Regulator

A generator regulator is designed for one purpose only and that is to regulate or control the charging rate in the generator-battery circuit. When a good battery is low, the regulator will automatically increase the charging rate until the battery becomes fully charged. As soon as the battery is charged up, the regulator will automatically cut down the charging rate. That's all it does.

Operation of Regulator

The modern regulator consists of three units shown in Fig. 1. The circuit breaker (or cutout relay) is the same type as and functions exactly like the conventional circuit breadker that has always been used on cars; it automatically closes the circuit between the generator and battery when the engine is running a little above idling speed, and it opens the circuit when the engine is idling or stopped. In other words, it is simply a magnetic switch.

The voltage and current regulators, regardless of type, are automatic magnetic switches that weaken or strenghten the generator field circuit according to the requirements of the battery. This is accomplished by means of resistances that atuomatically cut into or out of the field circuit.

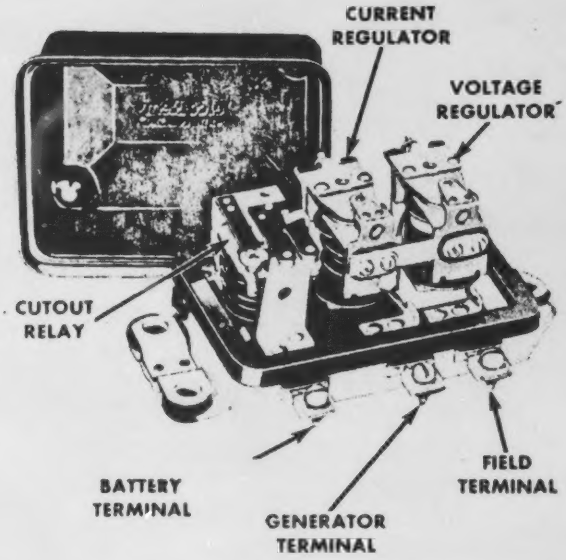


Fig. 1 *Delco-Remy generator regulator with cover removed*

In other words, when the battery is not fully charged resistance is cut out of the circuit, thereby allowing the generator to recharge the battery. When the battery becomes fully charged, resistance is automatically cut into the circuit. reducing the charging rate of the generator so that the battery voltage is held within safe limits.

Before we describe the operation of a typical regulator, you will recall that if a wire is wound around a soft iron rod, and a current is passed through the wire,the rod becomes a magnet. Its magnetism depends upon the number of turns of wire and the amperage. To put it briefly, therefore, the regulator consists of three electromagnetic switches which interrupt the circuits automatically and at the proper time. In an electromagnetic circuit interrupter, the magnet acts on a hinged spring-loaded piece called an armature, thereby closing or opening the circuit contacts at predetermined voltages and amperages.

How a Regulator Works

Although the following describes the operation of a modern Delco-Remy regulator, it has been selected because two types are in general use. The so-called single contract type, Fig. 2, is used on standard cars and the double-contact type is used on air conditioned cars, Fig. 3. Bear in mind, however, that the fundamental principles of operation also apply to the Prestolite, Ford and Bosch regulators even though their construction differs somewhat from Delco-Remy regulators.

Usually the regulator is grounded through its attaching bolts, and to insure positive ground the base of the regulator is often connected by a wire to the generator frame or housing.

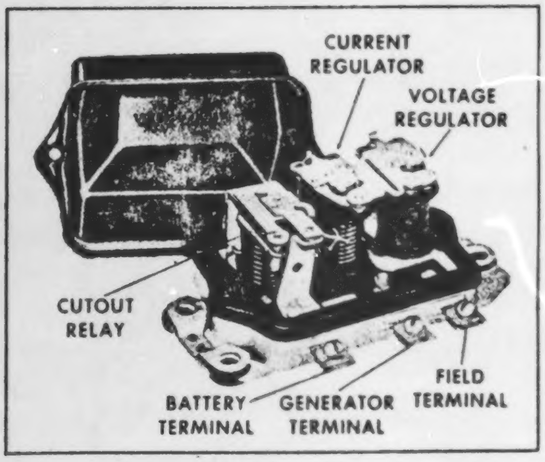

CURRENT REGULATOR
VOLTAGE REGULATOR
CUTOUT RELAY
FIELD TERMINAL
BATTERY TERMINAL
GENERATOR TERMINAL

Fig. 2 *Delco-Remy generator regulator for cars without air conditioning*

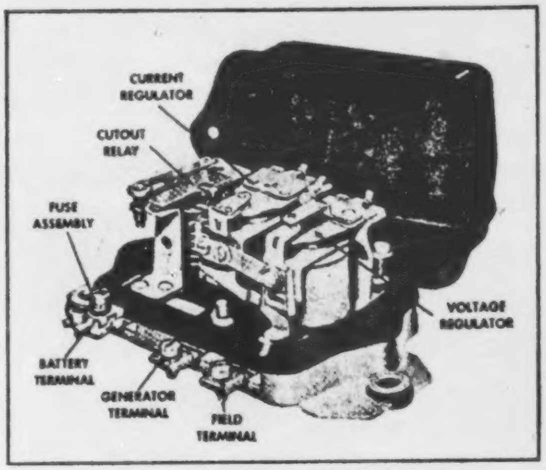

CURRENT REGULATOR
CUTOUT RELAY
FUSE ASSEMBLY
VOLTAGE REGULATOR
BATTERY TERMINAL
GENERATOR TERMINAL
FIELD TERMINAL

Fig. 3 *Delco-Remy generator regulator for air conditioned car*

Cutout Relay

The cutout relay opens the circuit to prevent the battery from discharging to ground through the generator whenever the engine is topped or generator is operating at such low speed that its voltage is less than voltage of battery. When the voltage of generator is slightly greater than battery voltage the relay closes the circuit so that generator can furnish current to the electrical system

The cutout relay has a series of current winding of a few turns of heavy wire, and a shunt or voltage winding of many turns of fine wire, both assembled on the same core. The shunt winding is connected between generator armature and ground so that generator voltage is impressed upon it at all times. The series winding is connected so that all generator output current must pass through it. It is connected to a flat steel armature which has a pair of contact points through which current passes to the battery and other electrical units. The contact points are held open by armature spring tension when the unit is not operating, Figs 4,5.

When the generator begins to operate. voltage builds up and forces current through the shunt winding, thereby magnetizing the core. When the voltage reaches the value for which the relay is set, the magnetism is strong enough to overcome the armature spring tension and pull the armature toward the core, thereby closing the contact points. Generator current now flows through the series winding of relay in the right direction to add to the magnetism holding the points closed, and passes on to the battery and other electrical units in operation.

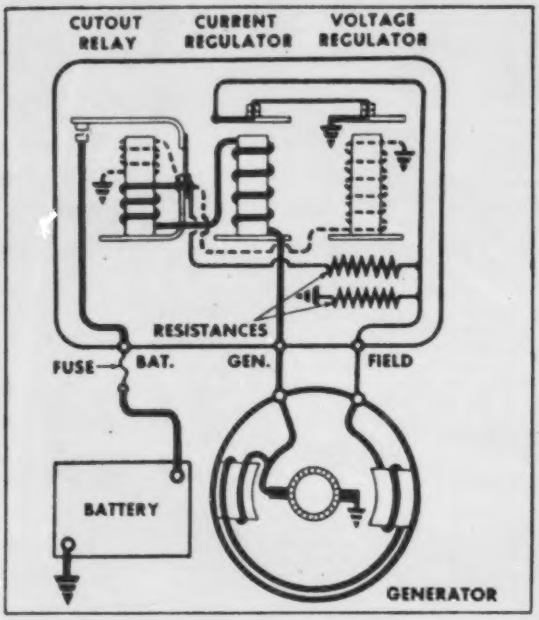

CUTOUT RELAY
CURRENT REGULATOR
VOLTAGE REGULATOR
RESISTANCES
FUSE
BAT.
GEN.
FIELD
BATTERY
GENERATOR

Fig. 4 *Generator system circuit for car without air conditioning*

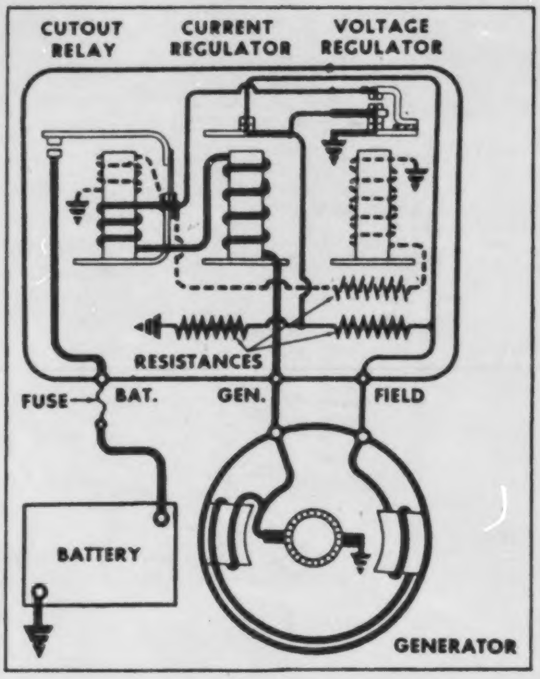

CUTOUT RELAY
CURRENT REGULATOR
VOLTAGE REGULATOR
RESISTANCES
FUSE
BAT.
GEN.
FIELD
BATTERY
GENERATOR

Fig. 5 *Generator system circuit for air conditioned car*

When the generator slows to engine idling speed, or stops, current begins to flow from the battery back through the generator, reversing the current flow through the series winding. This reduces the magnetism of the relay core to the extent that it can no longer hold the contact points closed against armature spring tension. The points are separated and the circuit broken between the generator and battery.

Both standard and air condition regulators have a fuse in the generator charging circuit. This fuse connects to the battery terminal of the regulator and the battery lead connects to it in turn. The purpose of the fuse is to protect the generator and wiring should a stuck or welded cutout relay occur. Shorts or grounds occurring in the charging circuit or reverse polarity conditions of the generator can cause the cutout relay points to weld together. This allows the battery to discharge thru the generator when the generator is not developing greater than battery voltage. Since the generator has such low internal resistance, tremendously high current will flow from the battery causing wiring to burn and deterioration of the generator.

Current Regulator

The current regulator automatically controls the maximum output of the generator. When the current requirements of the electrical system are large and the battery is low,the current regulator operates to protect the generator from overload by limiting its output to a safe value.

The current regulator has one series winding of heavy wire through which the entire generator output flows at all times. This winding connects to the series winding in the cutout relay,described above. Above the winding core is an armature, with a pair of contact points which are held together by spring tension when the current regulator is not operating. When the current regulator is not operating and the contact points are closed, the generator field circuit is directly grounded os theat the generator may produce maximum output unless further controlled by the voltage regulator described further on.

When the generator output increases to the value for which the current regulator is set, the magnetism of the current winding is sufficient to overcome the armature spring tension. The armature is pulled toward the winding core so that the points are separated. The generator fiedl circuit must then pass through a resistance which reduces the flow through the field coils and thereby reduces the output of the generator. This reduces the magnetic strenght of the current winding so that spring tension again closes the contact points, directly grounding the generator field circuit and increasing generator output. This cycle is repeated many times a second, and this action limits the generator output to the value for which the generator is set.

The current regulator has a bi-metal hinge on the armature for thermostatic temperature control. This automatically permits a somewhat higher generator output when the unit is cold, and causes the output to drop off as the temperature increases.

The current regulator operates only when the condition of battery and the load of current-consuming units in operation require maximum output of the generator. When requirements are small, the voltage regulator controls generator output. Either the current regulator or voltage regulator operates at any one time; both regulators never operate at the same time.

Voltage Regulator

The voltage regulator limits the voltage in the charging circuits to a safe value, thereby controlling the charging rate of the generator in accordance with the requirements of the battery and the current-consuming electrical units in operation. When the battery is low, the generator output is near maximum but as the battery comes up to charge, and other requirements are small, the voltage regulator operates to limit the voltage, thereby reducing the generator output. This protects the battery from overcharge and the electrical system from high voltage.

The voltage regulator unit has a shunt winding consisting of many turns of fine wire which is connected across the generator. The winding and core are assembled into a frame. A flat steel armature is attached to the frame by a flexible hinge so that it is just above the end of the core. When the voltage regulator unit is not operating, the tension of a spiral spring holds the armature away from the core so that a point set is in contact which allows the generator field circuit to complete the ground through them, Figs. 4 and 5.

When the generator voltage reaches the value for which voltage regulator is set, the magnetic pull of the voltage winding is sufficient to overcome the armature spring tension so that the armature is pulled toward the core and the contact points are separated. The instant the points separate, the field current flows only through the resistance to ground. This reduces the current flow through the field coils and decreases generator voltage and output.

The reduced voltage in the circuit causes a weakening of the magnetic field fo the voltage winding in the regulator. The resulting loss of the magnetism permits the spring to pull the armature away from the core and close the contact points again, thereby directly grounding the generator field so that generator voltage and output increases.

This cycle is repeated many times a second, causing a vibrating action of the armature,and holds the generator voltage to a constant value. By maintaining a constant voltage, the voltage regulator continues to reduce the generator output as the battery comes up to charge. When the battery reaches a fully charged condition, the voltage regulator will have reduced the generator output to a relatively few amperes.

The voltage regulator has a bi-metal armature hinge for thermostatic temperature control. This automatically permits regulation to a higher voltage when the unit is cold,and a lower voltage when hot, because a high voltage is required to charge a cold battery.

As previously stated, the current and voltage regulators do not operate at the same time. When current requirements are large, the generator voltage is too low to cause voltage regulator to operate, therefore the current regulator operates to limit maximum output of generator. When current requirements are small, the generator voltage is increased to the value which causes voltage regulator to operate. The generator output is then reduced below the value required to operate the current regulator, consequently all control is then dependent on the operation of voltage regulator.

Double Contact Voltage Regulator

Two sets of points are required in the voltage control to handle the high field current used in the heavy duty generator Fig. 5.

The voltage regulator armature has two contact points which are just over and under stationary contact points. When the voltage regulator unit is not operating, the tension of the spiral spring holds the armature away from the core so that the lower set of contacts is closed and the generator field current is completed directly to ground through them Fig. 5.

When the voltage regulator unit is controlling generator output, there are two operating conditions which result in entirely different action of the voltage regulator:

1. When the engine speed is low and there is a great demand for current by the accessories and/or battery, generator field current flow must be high. Under this operating condition, the voltage regulator vibrates on the lower set of contacts. When these contacts are closed, field current flows directly to ground; when they are open, current flows through a resistor to ground. Field current will therefore be somewhere between that allowed by the resistor and a direct ground.

2. When engine speed is high and there is little demand for current by the accessories or battery, generator field current flow must be regulated to a very low value; the resistance inserted in the field circuit when the lower contacts open is not sufficient to control the generator voltage. Under this operating condition, the voltage increases slightly (.1 to .3 volt), the armature is pulled farther down, and the voltage regulator operates on the upper set of contacts.

When these contacts are open, field current flows through the resistor to ground, when they are closed, field current is stopped due to current from the charging circuit bucking against the field flow, Fig. 5. Field current will therefore be somewhere between that allowed by the resistor and zero.

Resistances

The current or voltage regulator circuit both use the same resistance which is inserted in the field circuit when either regulator operates.

The sudden reduction in field current occurring when either the current or voltage regulator contacts open, is accomplished by a surge of induced voltage in the field coils as the strength of the magnetic fields change. These surges are partially dissipated by the two resistances, thus preventing excessive arcing at the contact points.

Electrical Competencies - Charging System

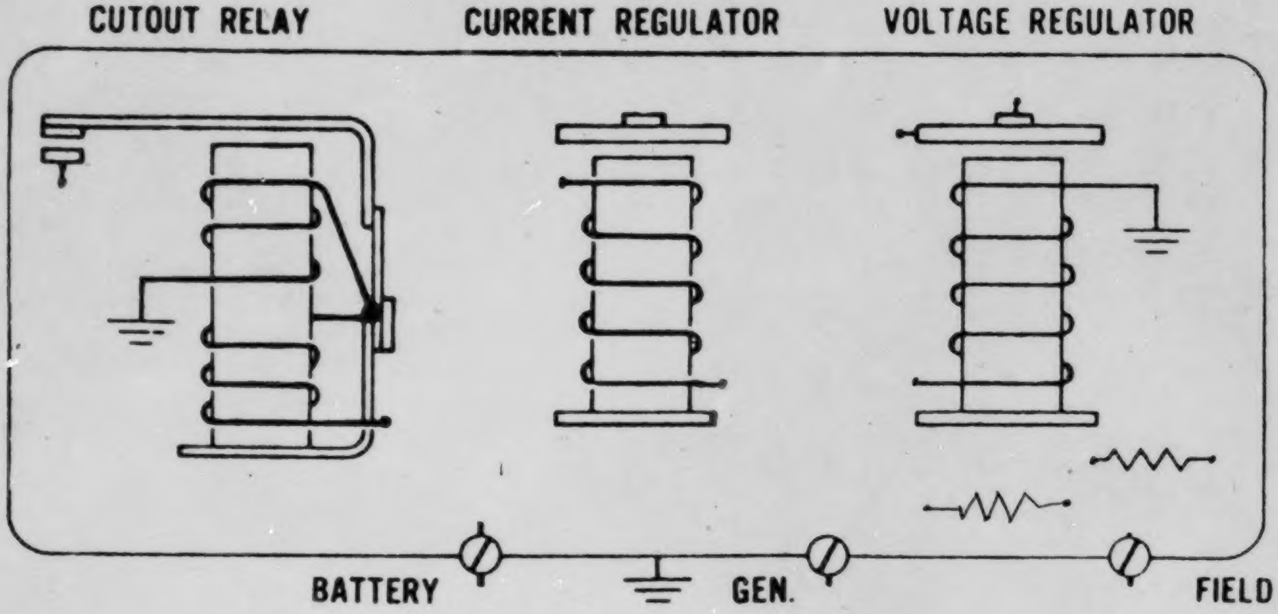
No. C-7 D C Regulator Operation

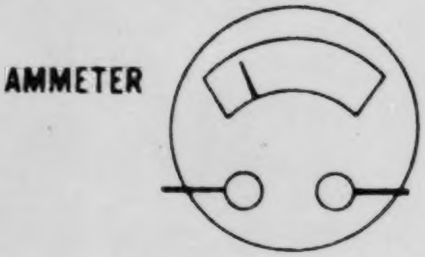
Worksheet # 1

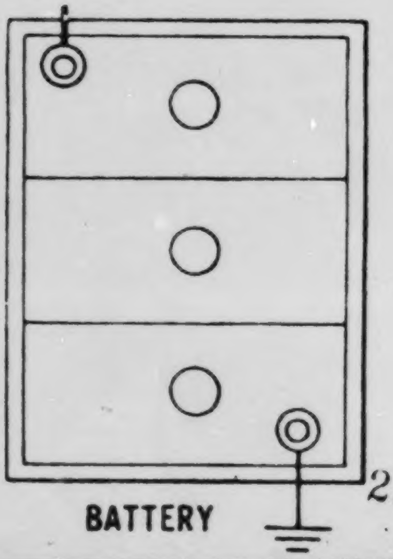
Name ______________________________ Date ____________ Grade ______

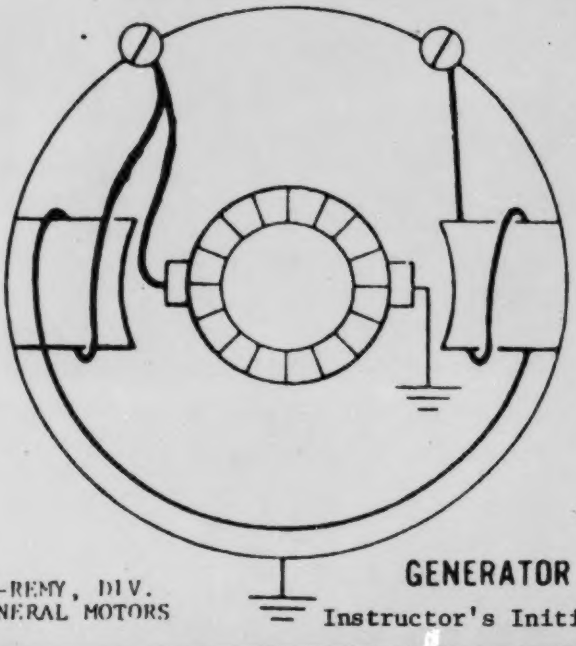
DIRECTIONS: Make the necessary eletrical connections on the diagram using your pencil.

GENERATOR-REGULATOR A CIRCUIT


CUTOUT RELAY
CURRENT REGULATOR
VOLTAGE REGULATOR
BATTERY
GEN.
FIELD







DELCO-REMY, DIV.
OF GENERAL MOTORS
CORP.

Instructor's Initials_____

Electrical Competencies - Charging System

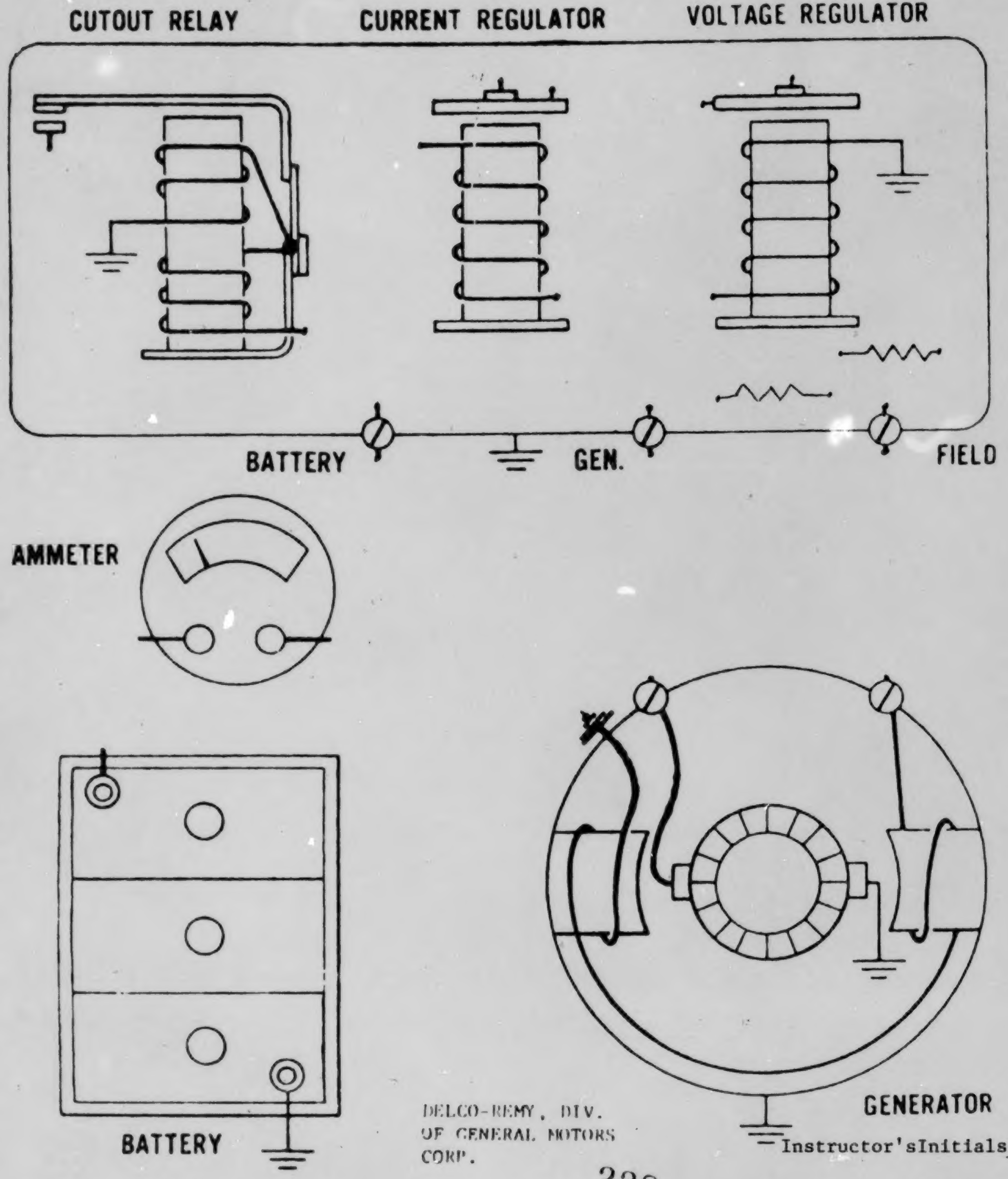
No. C-7 D C Regulation Operation

Worksheet # 2

Name ______________________________ Date ____________ Grade ____________

DIRECTIONS: Make the necessary electrical connections on the diagram using your pencil.

GENERATOR-REGULATOR B CIRCUIT


CUTOUT RELAY
CURRENT REGULATOR
VOLTAGE REGULATOR
BATTERY
GEN.
FIELD
AMMETER
BATTERY
GENERATOR

DELCO-REMY, DIV.
OF GENERAL MOTORS
CORP.

Instructor's Initials ________

AUTO MECHANICS

Electrical Competencies - Charging System

No. C-8 Alternator Regulator Operation

OBJECTIVE: Upon completion of this exercise, you should be able to understand the basic operation of an alternator regulator and the different types of regulators.

EXPLANATION: Information sheet # 4 explains the need for regulation, operation of regulators and the different types of regulators in use.

MATERIALS NEEDED:

TOOLS NEEDED:

References	Do
#1. Ch. 22 (29-41)	I. Study references assigned.
#2. p. 389 -391	2. Study information sheet.
#3. p. 572-630	3. Complete worksheet
#4. p. 363-380	4. Check with instructor
#5. p. 191-199	
#6. p. 284-289	
#7. p. 252-255	
#8. --	

Electrical Competencies - Charging System

No. C-8 Alternator Regulator Operation

Information Sheet # 4

Regulators for Alternators

Need for Regulation

Alternators need regulation, just as dc generators do. There are significant differences, however. The alternator does not need a current regulator. Current regulation is inherent in the design of the unit. As long as the voltage is regulated, or kept at the specified level, the alternator cannot produce an excessive amount of current. Thus only the voltage requires regulation, as explained in the following paragraph.

The stator can remain permanently connected to the battery because the diodes in the stator-to-battery circuit prevent the battery from discharging through the stator windings when the engine is not running. Thus no cutout relay is needed (as required with dc generators). The field winding, however, must be disconnected when the engine stops. This is done through a field relay on many installations. On some systems, the field is connected to the battery directly through the ignition switch. When the ignition switch is turned on, the field is connected to the battery.

Some regulators are of the vibrating-contact type, others are of the transistor, or solid, type. Solid-state regulators have no moving parts but regulate through transistor action. Various regulators are described in following sections.

One-Unit Voltage Regulator

A one-unit voltage regulator is shown in Fig. 1. The wiring circuit of this regulator and the alternator with which it is used is shown in Fig. 2. When the ignition switch is turned on, the battery is connected directly to the field winding of the alternator through special contacts in the switch. This causes a magnetic field to build up in the field winding. Now, when the rotor begins to turn, alternating current is produced in the stator windings. This current is rectified and passed directly to the batter. When the voltage increases to the value for which the regulator has been set, the magnetism of the regulator winding is strong enough to pull the regulator armature down. This separates the lower set of contracts and inserts resistance into the alternator field circuit. The field strength is reduced and the voltage drops. As the voltage drops, the magnetic field in the regulator winding is weakened. Now the armature is released by the regulator winding and it moves up, thereby closing the lower contacts again. The cycle is repeated very rapidly, providing adequate voltage regulation during the low and intermediate speed ranges.

At higher speeds, with a fully charged battery, the resistance is not sufficient to hold the voltage down. Therefore the voltage starts to climb above the preset value of the lower contacts, even with the resistance in the field circuit. When this happens, the increased magnetic strength of the regulator winding (produced by the increased voltage) pulls the armature still further down. This added movement causes the upper contact points to close. When this happens, the field circuit is grounded in the regulator. Now both ends of the field winding are grounded (the other end is grounded in the alternator). The magnetic strength of the field is rapidly reduced, the alternator voltage falls off, and the magnetic strength of the regulator winding is weakened (because the voltage is reduced). The regulator armature therefore can move up, opening the upper contact points. The field circuit is now reconnected to the battery, either through the lower contacts or through the resistance. Voltage goes up and the cycle is repeated.

To sum up, during low-to-intermediate speed, when the battery is in a charged condition and the current demands are low, the voltage will increase sufficiently to cause the regulator lower contacts to vibrate. This provides voltage regulation up through intermediate speed. A higher speeds, added regulation is needed, and this provided by grounding the field circuit in the regulator through the upper contacts. Thus, at higher speeds, regulation is provided by vibration of the upper contacts.

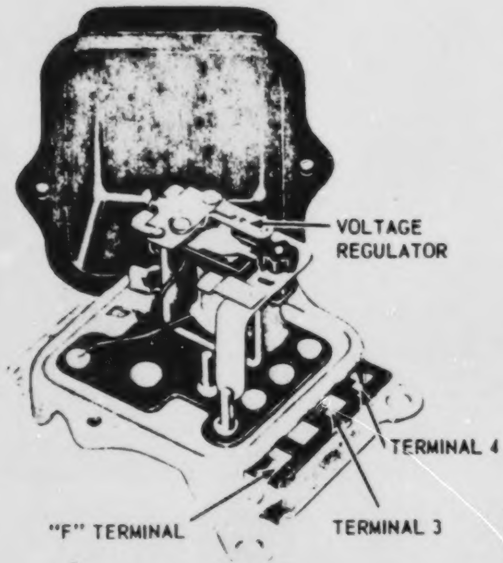


Fig. 1 An ac voltage regulator with its cover removed so that the unit can be seen. (*Pontiac Motor Division of General Motors Corporation*)

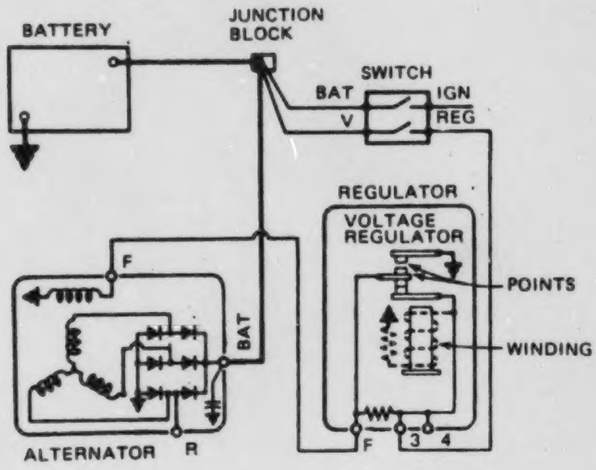


Fig.2 Wiring circuit of a one-unit ac regulator and alternator. (*Pontiac Motor Division of General Motors Corporation*)

Two-Unit Voltage Regulator

One type of two-unit voltage regulator is shown in Figs. 3 and 4, which show the regulator and the wiring circuit of the charging system. The two-unit regulator is similar to the one-unit regulator previously discussed. Added to this unit is a field relay, the operation of which is explained below. The regulator terminals are of the slip-connector type; a connector body on the vehicle wiring harness is keyed to mating terminal tabs on the regulator to ensure proper connections. A latch on the regulator base holds the connector body in place on the terminals

The regulator has four terminals -- F, 2, 3, and 4 -- as shown in Fig.4. Refer to this illustration as you study the following explanation of how the regulator operates. When the ignition switch is open, the field relay is open and the voltage regulator is not operating. The diodes in the alternator prevent the battery from discharging through the alternator.

When the ignition switch is closed and before the engine starts, the indicator light goes on to indicate that the alternator is not charging. With this condition, the current is flowing from the battery to the battery terminal of the ignition switch: through the resistor and indicator light, which are in parellel; and then through the regulaor lower contact points (via terminal 4). From there it flows on through the alternator field winding to ground and then back to the grounded terminal of the battery. This current flowing through

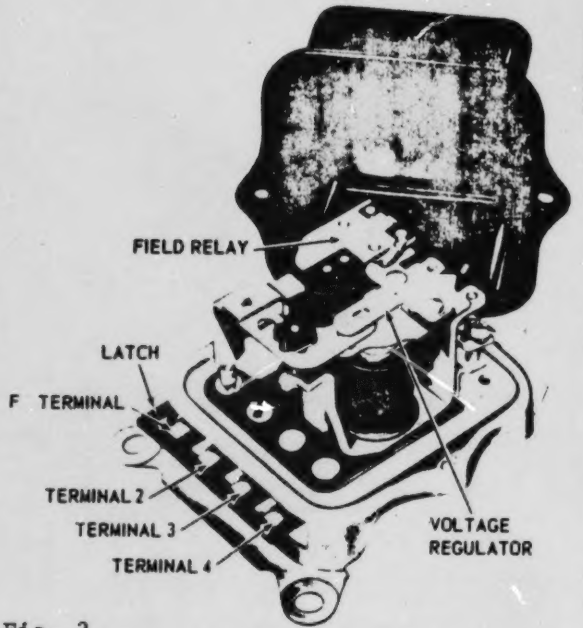

FIELD RELAY
LATCH
F TERMINAL
TERMINAL 2
TERMINAL 3
TERMINAL 4
VOLTAGE REGULATOR

Fig. 3 An ac two-unit regulator with its cover removed so that the units can be seen. The two units are a field relay and a voltage regulator. (*Delco-Remy Division of General Motors Corporation*)

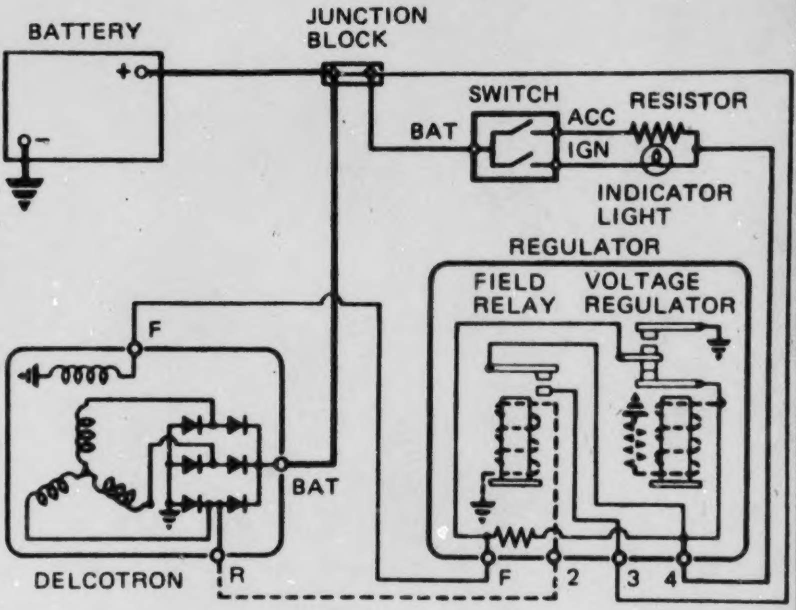

BATTERY
JUNCTION BLOCK
SWITCH
BAT
ACC
IGN
RESISTOR
INDICATOR LIGHT
REGULATOR
FIELD RELAY
VOLTAGE REGULATOR
F
BAT
DELCOTRON
R
F
2
3
4

Fig. 4 Wiring circuit of a two-unit ac regulator and alternator. (*Delco-Remy Division of General Motors Corporation*)

the field winding is great enough to produce a magnetic field sufficiently large to cause a voltage buildup in the stator windings when the engine starts.

After the engine starts and the alternator rotor begins to turn, voltage builds up in the stator windings and this produces a flow of current to the battery. The stator voltage is impressed on the winding in the field relay (via the R terminal on the alternator and terminal 2 on the regulator). The relay contacts therefore close, connecting terminal 4 of the regulator directly to the battery (through terminal 3). Now, both sides of the indicator light are connected to the same battery terminal and there is no voltage on it. Therefore the light goes out, indicating that the alternator is charging. Field current for the alternator now flows trom terminal 4, through the voltage-regulator lower contact points, and then through terminal F to the F terminal on the alternator.

As alternator speed increases, the voltage at the battery terminal of the alternator increases. This increasing voltage is impressed on the voltage-regulator winding. When the voltage reaches the value for which the regulator is set, the regulator armature is pulled down, causing the lower contact points to open. This inserts resistance into the field current and alternator voltage. The reduced voltage can no longer hold the lower contact points open and they close to allow an increased field current and alternator voltage. This action is repeated many times a second to limit the voltage to the preset value.

With still higher alternator speed, the resistor does not provide sufficient control of the alternator voltage. As the voltage therefore increases slightly, this higher voltage causes the upper contacts to close, they connect the field winding to ground. With both ends of the field winding connected to ground, the winding is shorted out and alternator voltage drops off. When this happens, the reduced voltage allows the upper contacts to open, so the voltage once more increases. A vibrating action takes place, with the upper contacts opening and closing many times a second.

Thus either the lower set of contact points is opening and closing(at lower speeds) or the upper set is opening and closing (at higher speeds). This limits the alternator voltage to safe values throughout the alternator speed range.

Ford Regulator with Field Relay

Figure 5 is the wiring circuit of a recent Ford 70-amp alternator and regulator with field relay. This wiring circuit is essentially to the Delco-Remy regulator with field relay shown in Fig. 4. The voltage regulators both work the same way. Compare the two circuits. Note that the charge-indicator light will come on when the ignition switch is closed. It will go off when the field relay closes its points. Note also that this circuit shows the connection of the electric choke heater. The electric choke heater is a small heater placed inside the carburetor choke. Its purpose is to speed up the choke action so that the choke opens quickly after the engine starts. This reduces the time that the engine operates with the choke closed and thus reduces pollutants from the engine.

Figure 7 is the wiring circuit of the same alternator and regulator with an ammeter rather than a charge indicator light. Note that the ignition switch is connected differently. It is connected directly to the S terminal of the regulator. When the ignition switch is closed, it connects the field relay to the battery to the field terminal of the regulator. The alternator field is now supplied with current so that a magnetic field develops. This magnetic field, sweeping through the stator windings, produces current. This is ac current, which is rectified by the diodes. The resulting direct current flows through the ammeter to the battery.

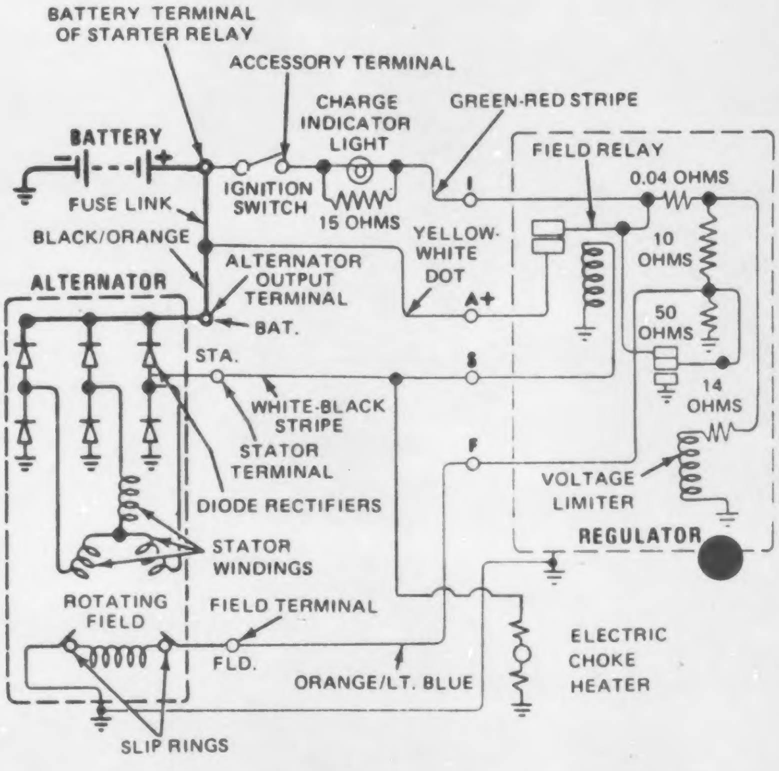

BATTERY TERMINAL OF STARTER RELAY
ACCESSORY TERMINAL
CHARGE INDICATOR LIGHT
GREEN-RED STRIPE
BATTERY
FIELD RELAY
0.04 OHMS
IGNITION SWITCH
I
FUSE LINK
15 OHMS
YELLOW-WHITE DOT
BLACK/ORANGE
10 OHMS
ALTERNATOR OUTPUT TERMINAL
ALTERNATOR
A+
BAT.
50 OHMS
STA.
S
WHITE-BLACK STRIPE
14 OHMS
STATOR TERMINAL
F
VOLTAGE LIMITER
DIODE RECTIFIERS
REGULATOR
STATOR WINDINGS
ROTATING FIELD
FIELD TERMINAL
ELECTRIC CHOKE HEATER
FLD.
ORANGE/LT. BLUE
SLIP RINGS

Fig. 5 Circuit diagram of an alternator and vibrating-contact voltage regulator with a field relay and a charge indicator light. (*Ford Motor Company*)

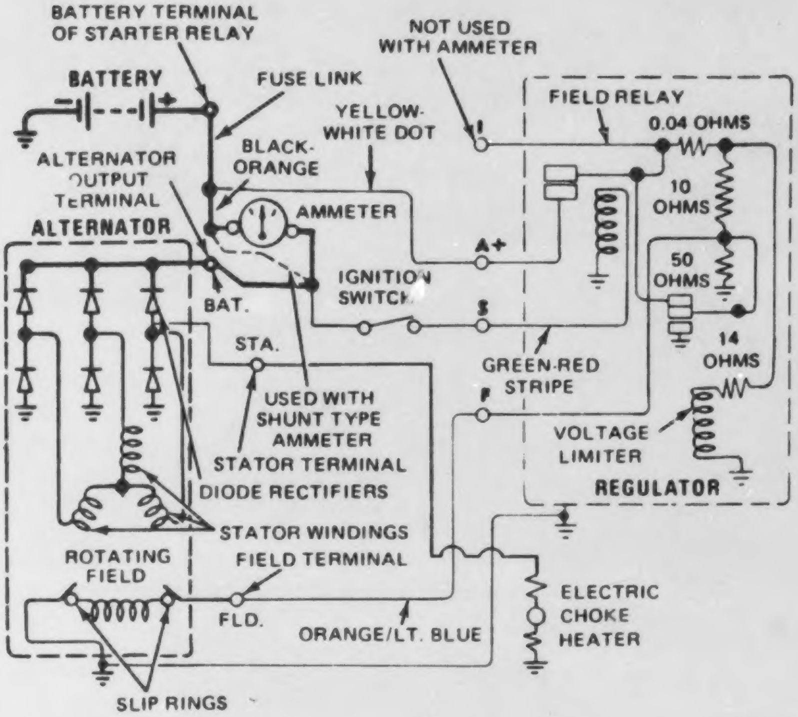

BATTERY TERMINAL OF STARTER RELAY
NOT USED WITH AMMETER
BATTERY
FUSE LINK
FIELD RELAY
YELLOW-WHITE DOT
0.04 OHMS
ALTERNATOR OUTPUT TERMINAL
BLACK-ORANGE
10 OHMS
AMMETER
ALTERNATOR
A+
50 OHMS
IGNITION SWITCH
BAT.
S
STA.
GREEN-RED STRIPE
14 OHMS
USED WITH SHUNT TYPE AMMETER
F
VOLTAGE LIMITER
STATOR TERMINAL
DIODE RECTIFIERS
REGULATOR
STATOR WINDINGS
ROTATING FIELD
FIELD TERMINAL
ELECTRIC CHOKE HEATER
FLD.
ORANGE/LT. BLUE
SLIP RINGS

Fig. 6 Circuit diagram of an alternator and vibrating-contact regulator with a field relay and an ammeter. (*Ford Motor Company*)

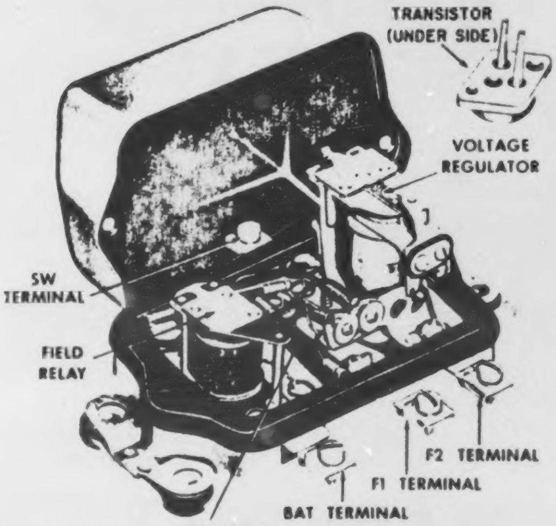

TRANSISTOR (UNDER SIDE)
VOLTAGE REGULATOR
SW TERMINAL
FIELD RELAY
F2 TERMINAL
F1 TERMINAL
BAT TERMINAL
RESISTOR

Fig. 7 Transistorized regulator with vibrating contact points for use with ac generators. The transistor is shown removed from the underside of the regulator. (*Delco-Remy Division of General Motors Corporation*)

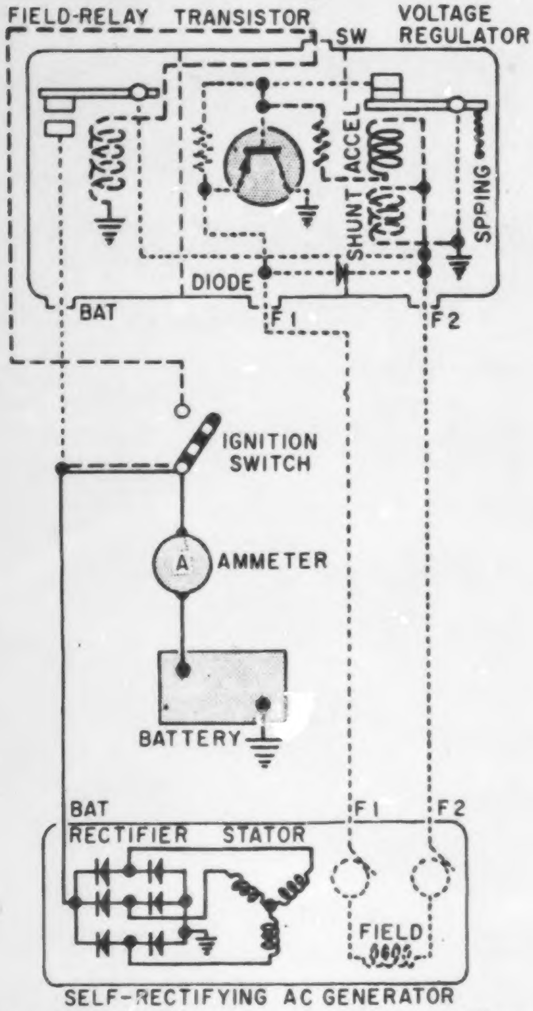

FIELD-RELAY
TRANSISTOR
VOLTAGE REGULATOR
SW
ACCEL
SHUNT
SPRING
DIODE
BAT
F 1
F 2
IGNITION SWITCH
A
AMMETER
BATTERY
BAT
F 1
F 2
RECTIFIER
STATOR
FIELD
SELF-RECTIFYING AC GENERATOR

Fig. 8 Wiring circuit of a transistorized regulator with vibrating contact points for use with an ac generator. *(Delco-Remy Division of General Motors Corporation)*

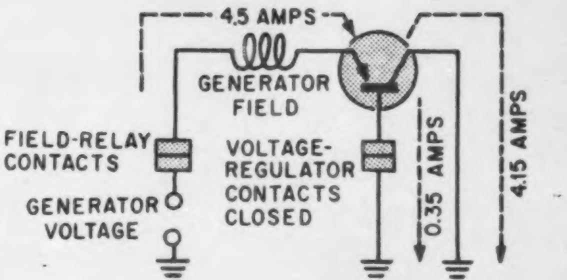

4.5 AMPS
GENERATOR FIELD
FIELD-RELAY CONTACTS
VOLTAGE-REGULATOR CONTACTS CLOSED
GENERATOR VOLTAGE
0.35 AMPS
4.15 AMPS

Fig. 9 With voltage-regulator contact points closed, current can flow through the transistor.

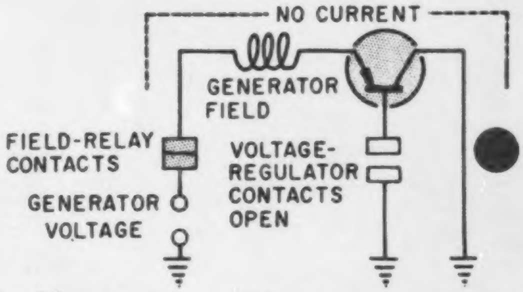

NO CURRENT
GENERATOR FIELD
FIELD-RELAY CONTACTS
VOLTAGE-REGULATOR CONTACTS OPEN
GENERATOR VOLTAGE

Fig. 10 With voltage-regulator contact points open, current stops flowing through the transistor.

Regulator with Transistor and Contact Points

Several types of regulators, partly or fully transistorized, have been used. One regulator using a transistor and vibrating contact points is shown in Fig. 7 and 8. The regulator contains two units, a field relay and a vibrating voltage regulator. The regulator and transistor work together to control alternator-field current and thus alternator voltage.

Before we examine the regulator circuit in detail let us look at the action of the transistor and the voltage-regulator contact points (Fig. 9 and 10). The field relay closes its contact points when the ignition switch is closed. This completes the alternator-field circuit through the transistor and the voltage -regulator contact points. When the alternator exceeds the value for which the voltage regulator is set, the voltage-regulator contact points open, thus opening the alternator-field circuit. The regulator contact points vibrate to provide regulation of the alternator voltage.

Now, let us look more closely at transistor action. You will recall that current will flow through a transistor from the collector to the emitter if the base helps by supplying current carriers. But if the base is disconnected that the supply of current carriers stops, then no current can flow through the transistor. This is what closing and opening the voltage-regulator contact points does. With the contact points closed, current carriers can appear at the base and a substantial current will flow through the transistor. With the contact points open, no current carriers appear and no current will flow.

Notice how only a small amount of current flowing through the contact points can control a much larger amount of current flowing through the transistor. Vibrating contact points can carry only a relatively small amount of current (1½ amps in a 12-volt system). This tends to limit field current and alternator output. But with the transistorized regulator, a much higher alternator-field current can be safely handled, since most of it flows through the transistor and not through the contact points.

If you will refer to Fig. 8 again, you will note that the upper winding in the voltage regulator is labeled "ACCEL" for (accelerator). This winding loses its magnetism entirely when the contact points open. The loss of magnetism speeds up the closing of the contact points. When the points close, this winding is reenergized to cause the contact points to open more rapidly. This faster contact-point movement results in a more even alternator voltage.

A variation of the regulator shown is Figs. 7 and 8 contains an indicator-light relay. The field relay is separately mounted. The circuit of this regulator is shown in Fig. 11. The indicator-light relay works as follows. When the ignition switch is turned on, the indicator light will come on and stay on until the alternator starts to charge the battery. When this happens, the relay opens and the light goes off.

The separately mounted field relay operates in the same way as the field relay mounted in the regulator. When the ignition switch is turned on, the

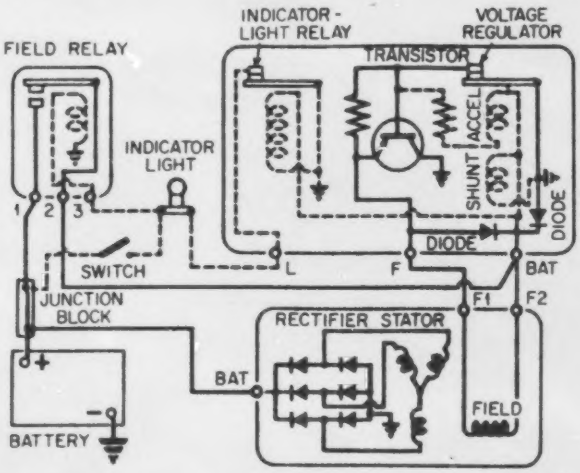


Fig. 11 Wiring circuit of a transistorized regulator with vibrating contact points for use with an ac generator. In this system, the field relay is separately mounted and an indicator-light relay is enclosed within the regulator. (*Delco-Remy Division of General Motors Corporation*)

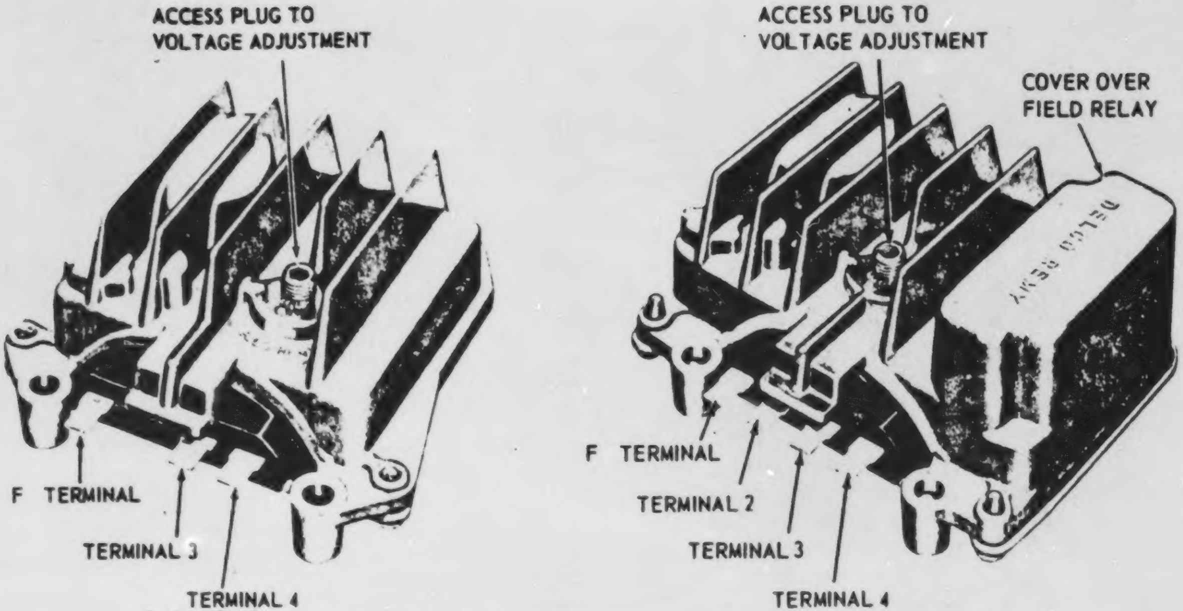


Fig.12 Typical transistorized regulators. *Left*, type without a field relay; *right*, type with a field relay. (*Delco-Remy Division of General Motors Corporation*)

field-relay winding is connected to the battery; this closes the relay, which then connects the alternator field to the battery.

Fully Transistorized Regulator

The fully transistorized regulator depends entirely upon transistor action for control of alternator voltage. It may or may not have an integral field relay. Figure 12 shows typical transistor regulators, without and with an integral relay. Figure 13 illustrates the complete wiring circuit of the regulator and alternator. This is the unit with the field relay. The functioning of the relay is similar to that of the relay in the two-unit regulator previously described. Figure 14 shows the wiring diagram of the regulator alone, with the active components named.

We will use the simplified wiring diagram shown in Fig. 15 to explain the action of the transistor. Note that the only internal part shown in the regulator is the output transistor (6 in Fig. 14). The other components are controlling and triggering devices to activate the output transistor. When the ignition switch is closed, battery current flows through the emitter (E) and collector (C) of the transistor to the field winding of the alternator. This emitter-collector circuit through the transistor is "turned on" because the control circuit is supplying current carriers (electrons) to the base (B) of the output transistor.

The flow of current through the output transistor and through the field winding of the alternator provides the magnetic field for the alternator. Then, when the engine is started so that the alternator rotor is turned, the alternator voltage builds up and the alternator supplies current.

As alternator speed increases, the alternator voltage continues to increase until it reaches the value for which the regulator is set. At this point. the control circuit of the regulator shuts off the supply of current carriers to the base of the output transistor. With this condition, the transistor is turned off and no current can flow through the emmitter-collector circuit in the transistor. This means that current stops flowing to the field winding, so that alternator voltage and output drop off. When the voltage drops off belwo the preset value, the control circuit begins to supply current carriers to the base of the output transistor. Now the transistor is turned on again, so current can once more flow to the field winding and alternator voltage increases. This action takes place very rapidly. Under some conditions, the off-on cycle repeats 7,000 times a second.

Now, let us look at the complete internal circuit of the regulator (Fig. 14) to find out how the control circuit starts or stops the flow of current carriers to the output-transistor base. First, note that there is a diode (2) and a resistor connected to the base of the driver transitor (4). When the voltage from the alternator (entering at terminal 3) reaches the preset value, it is high enough to break down the diode (2). When this happens, current flows through the diode in the reverse direction so that current carriers no longer move to the base of the dirver transistor. Now the direct circuit through the driver transistor (emitter-collector) stops supplying current carriers to the base of the output transistor. As a result, the current flow through the emitter-collector circuit of the output transistor is stopped. This stops the flow of current to the field winding, so the alternator voltage drops off. As soon as it falls below the preset value, the diode (2) can once again stop the flow of current through it in the reverse, or breakdown, direction. Thus, current carriers once again flow the base of the driver transistor and the driver tansistor again permits a flow of current carriers to the base of the output transistor. Now current can flow through the emitter-collector circuit fo the output transistor to the field windings of the alternator. The voltage then goes up and the cycle is repeated.

Ford Transistorized Regulator

The Ford transistorized regulator. which has a circuit similar to that shown in Fig. 13 is also adjustable. To adjust the voltage on this unit, you remove the cover as shown in Fig. 16 and turn the adjustment screw. Note that you turn the screw clockwise to increase the voltage setting. A fiber rod-not a metal screwdriver- must be used to make this adjustment so as to avoid the danger of shorting the transistor circuit.

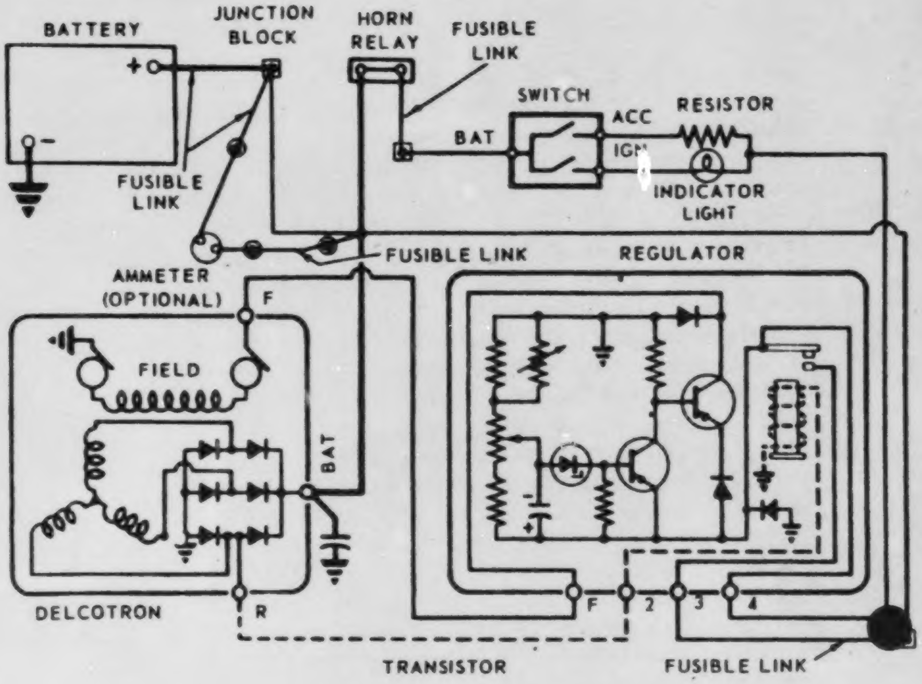
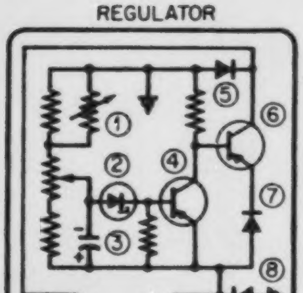

BATTERY
JUNCTION BLOCK
HORN RELAY
FUSIBLE LINK
SWITCH
ACC
IGN
BAT
RESISTOR
INDICATOR LIGHT
FUSIBLE LINK
FUSIBLE LINK
AMMETER (OPTIONAL)
REGULATOR
F
FIELD
BAT
DELCOTRON
R
F
2
3
4
TRANSISTOR
FUSIBLE LINK

Fig. 13 Wiring diagram of a transistorized voltage regulator with a field relay. (*Delco-Remy Division of General Motors Corporation*)


REGULATOR
①
②
③
④
⑤
⑥
⑦
⑧
F
3
4

1. Voltage adjuster
2. Diode
3. Capacitor
4. Driver transistor
5. Field discharge diode
6. Output transistor
7. Back bias diode
8. Transient suppressor diode

Fig.14 Internal circuit of a transistorized regulator. (*Delco-Remy Division of General Motors Corporation*)

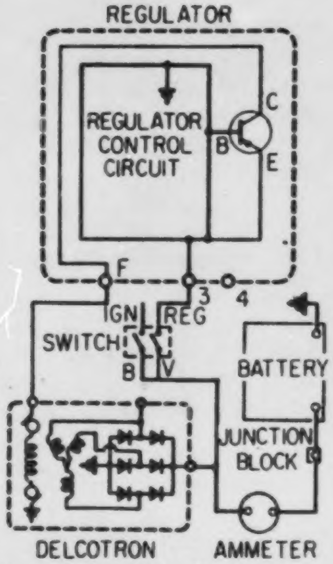

REGULATOR
REGULATOR CONTROL CIRCUIT
C
B
E
F
3
4
IGN
REG
SWITCH
B
V
BATTERY
JUNCTION BLOCK
DELCOTRON
AMMETER

Fig. 15 Simplified wiring circuit of a transistorized regulator and alternator. (*Delco-Remy Division of General Motors Corporation*)

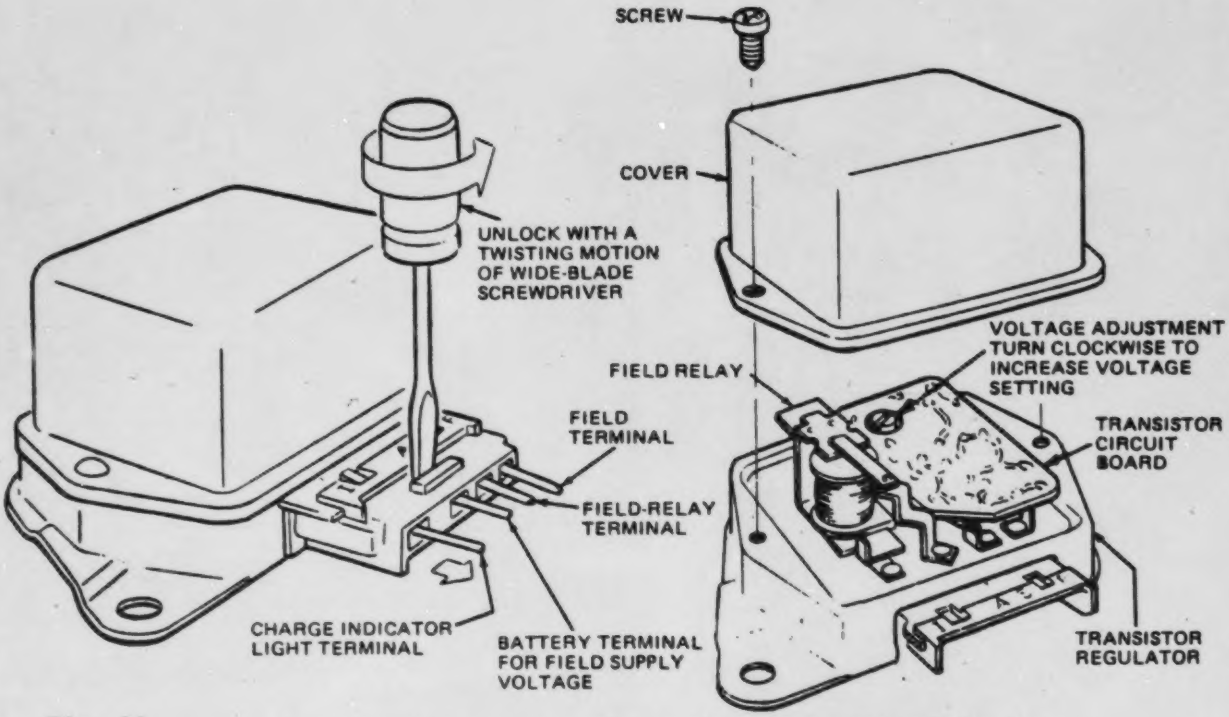

SCREW
COVER
UNLOCK WITH A TWISTING MOTION OF WIDE-BLADE SCREWDRIVER
VOLTAGE ADJUSTMENT TURN CLOCKWISE TO INCREASE VOLTAGE SETTING
FIELD RELAY
FIELD TERMINAL
TRANSISTOR CIRCUIT BOARD
FIELD-RELAY TERMINAL
CHARGE INDICATOR LIGHT TERMINAL
BATTERY TERMINAL FOR FIELD SUPPLY VOLTAGE
TRANSISTOR REGULATOR

Fig. 16 Transistorized alternator regulator with a field relay. The cover has been removed so that the voltage-adjustment screw can be seen. (*Ford Motor Company*)

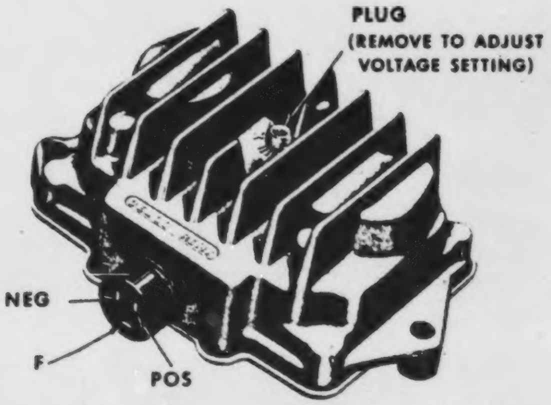

PLUG (REMOVE TO ADJUST VOLTAGE SETTING)
NEG
F
POS

Fig. 17 Heavy-duty transistorized regulator. (*Delco-Remy Division of General Motors Corporation*)

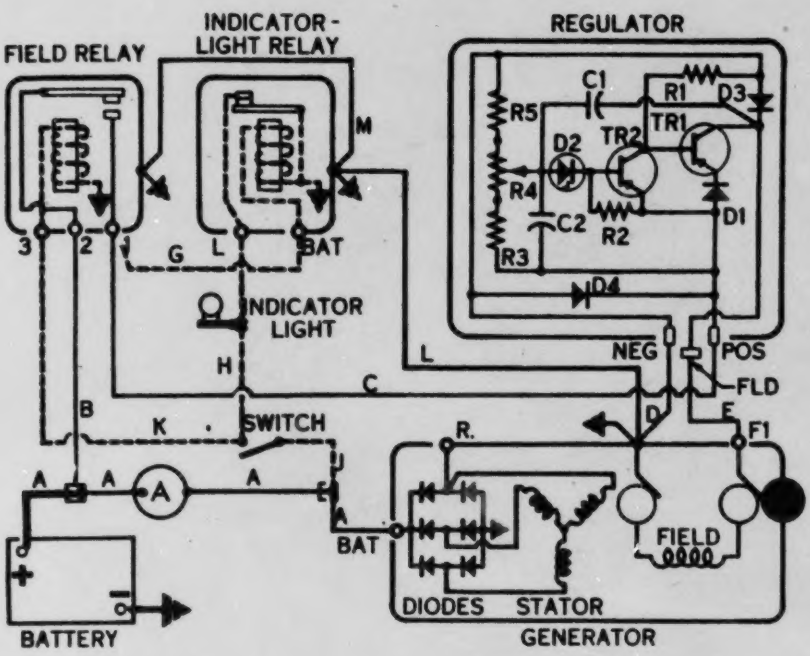

FIELD RELAY
INDICATOR-LIGHT RELAY
REGULATOR
C1
R1
D3
R5
TR2
TR1
D2
R4
C2
R2
D1
R3
D4
3
2
1
G
L
BAT
M
INDICATOR LIGHT
H
L
C
NEG
POS
FLD
D
E
F1
B
K
SWITCH
R.
A
A
A
A
BAT
FIELD
DIODES
STATOR
GENERATOR
BATTERY
+
−

Fig. 18 Wiring circuit of a heavy-duty transistor with a field relay and an indicator-light relay. *(Delco-Remy Division of General Motors Corporation)*

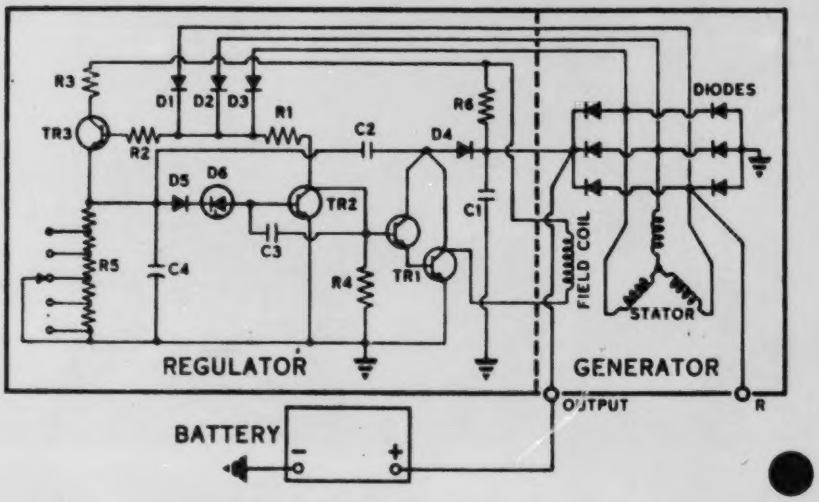

R3
D1
D2
D3
R1
C2
D4
R6
DIODES
TR3
R2
D5
D6
TR2
C1
C3
R5
C4
R4
TR1
FIELD COIL
STATOR
REGULATOR
GENERATOR
OUTPUT
R
BATTERY
−
+

Fig. 19 Wiring circuit of a Delcotron* Integral Charging System which is an alternator with integral rectifying diodes and a voltage regulator. *(Delco-Remy Division of General Motors Corporation)*

Heavy-duty Transistorized Regulator

The heavy-duty transistorized regulator (Fig. 17) is similar in appearance and circuitry to the unit previously described. However, the complete circuit includes a field relay and an indicator-light relay (Fig. 18). Their function is similar to that of the units described previously in the chapter. The regulator action is the same as for the regulators shown in Figs. 12 and 13. That is, when the preset voltage value is reached, the diode (D2) breaks down and drains current carriers from the driver-transistor base (TR2). This halts the flow of current through the driver transistor so that the base of the output transistor (TR1) is no longer supplied with current carriers. As a result, current stops flowing through the output transistor and the flow of current to the alternator field winding stops. The voltage drops and the diode is restored to its first condition, so current carriers are not longer drained from the base of the driver transistor. Thus current flows through the driver transistor to the base of the output transistor and, with current carriers available at the base, current now flows through the output transistor to the alternator field winding. Voltage and output go up and the cycle is repeated rapidly, many times a second.

Alternators with Integral Regulators

Several alternators now have integral regulators. That is, the regulators are a built-in part of the alternators. Figures 8 and 9 illustrate two of these. Figure 19 shows the circuit for the alternator and regulator illustrated in Fig. 9. The assembly is called an integral charging system by the manufacturer. As you read the explanation of how the regulator functions, keep referring to Fig. 19.

As the rotor begins to turn, the permanent magnetism in the rotor induces voltage in the stator winding. This voltage sends current through the following in the regulator: diodes D1, D2, and D3 and resistors R1 and R 4. Then it flows through the alternator diodes and back to the stator winding. The voltage turns on transistor TR 1 and the battery now supplies current to the field coil through resistor R6 and TR1.

Current also flows through diodes D1, D2, and D3, resistor R2, transistor TR3, and the voltage-adjusting resistor R5, causing TR3 to turn on. Current now flows through R6, R3, TR3, and R 5. With increasing speed and alternator buildup, voltage increases. The voltage across R5 is impressed across diodes D5 and D6, caused by current flow through R6, R3, and R5. When the preset voltage is reached, diodes D5 and D6 begin to conduct. This turns on TR2. TR1 turns off, and current flow through the field coil drops off. Alternator voltage therefore decreases. As this happens, diodes D5 and D6 and transistor TR2 all turn off. TR1 therefore turns on agion to permit field current and alternator voltage to increase. The whole cycle is repeated many times a second to limit the voltage to the value for which the voltage-adjusting resistor R5 is adjusted.

Capacitors C2 and C3 cause TR1 to turn on and off quickly. Diode D4 prevents high induced voltage in the field coil when TR1 turns off and the magnetic field in the field coil starts to collapse.

Capacitor C4 smooths out the voltage across R5. Resistor R6 raises the alternator voltage slightly as the output increases to maintain a more nearly constant voltage across the battery and thus compensate for line voltage drop. Capacitor C1 protects the alternator diodes from high transient, or surge, voltage and suppresses radio interference.

Figure 20 is the complete wiring diagram of an alternator with a built-in solid-state regulator. It is similar to the one shown in Fig. 19 and operates as follows. When the switch is turned on, current flows to alternator terminal 1, through resistor R1, diode D1, and the base-emitter of transistor TR1 to ground, and then back to the battery. This turns on TR1, and current flows through the alternator field and TR1 back to the battery. When the engine starts and the alternator rotor begins to turn, alternating voltage is built up in the stator windings. The six diodes in the rectifier bridge recitify the resulting current into direct current, which then flows to the battery. Some of the alternating current is rectified by the diode trio to feed the alternator field. (In other systems, a diode is not used, and field current is supplied through a field relay from the six diodes.)

As alternator speed and voltage increase, the voltage between R2 and R3 increases enough to force D2 to conduct. This turns TR2 on and TR1 off. With TR1 off, field current and alternator voltage are reduced and D2 then blocks current flow. This allows TR1 to turn back on again. Field current and alternator voltage once again increase, and the whole cycle is repeated many times a second to limit the alternator voltage to the preset value. Capacitor C1 smooths out the voltage across R3. R4 prevents excessive current through TR1 at high temperatures, and D3 prevents high induced voltages in the field winding when TR1 turns off.

The regulator has a form of temperature compensation. This ability permits increased voltage as regulator temperature is reduced. The purpose of this increase is to provide a higher voltage to charge a cold battery.

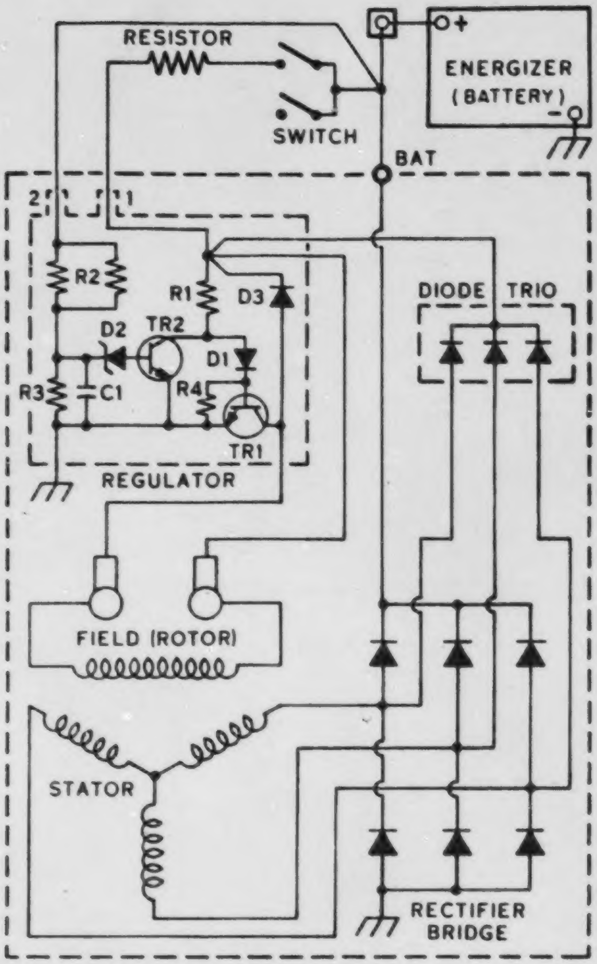

RESISTOR
SWITCH
ENERGIZER (BATTERY)
+
−
BAT
2
1
R2
R1
D3
D2
TR2
D1
R3
C1
R4
TR1
REGULATOR
DIODE TRIO
FIELD (ROTOR)
STATOR
RECTIFIER BRIDGE

Fig. 20 Wiring diagram of an alternator with integral diodes, a solid-state voltage regulator, and a diode trio to supply field current. (*Chevrolet Motor Division of General Motors Corporation*)

X

Electrical Competencies - Charging System

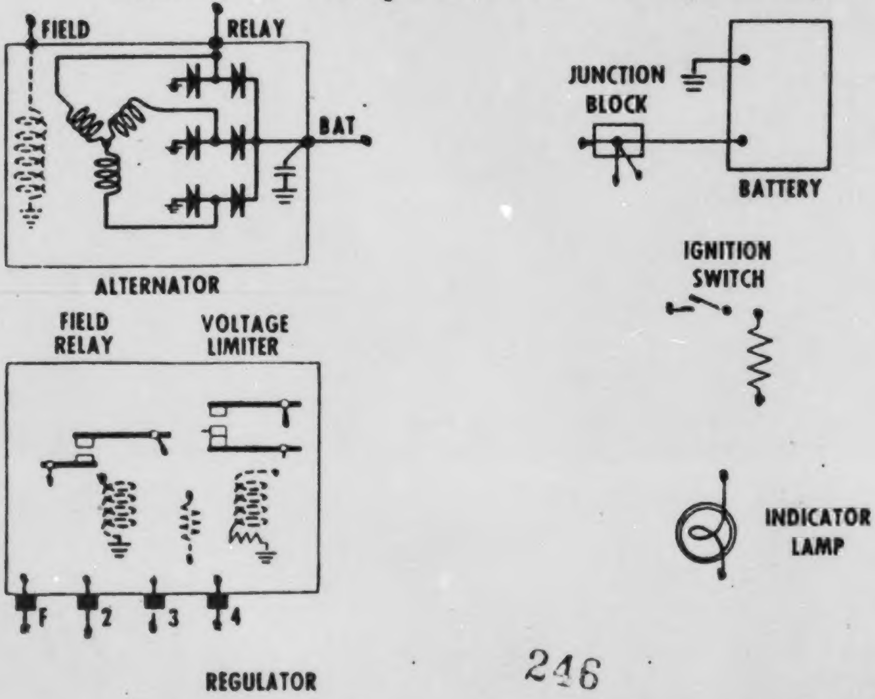
No. C-8 Alternator Regulator Operation

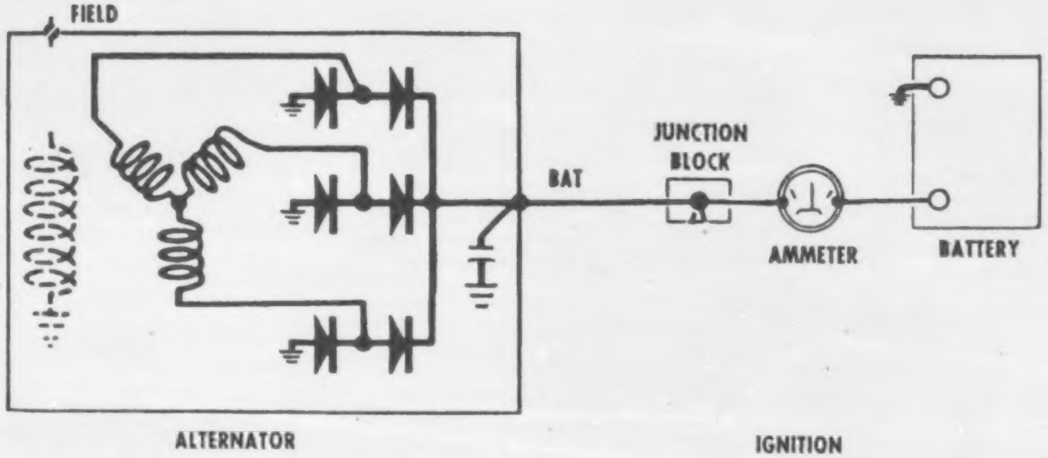
Worksheet # 1

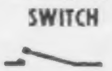
Name ______________________________ Date ____________ Grade __________

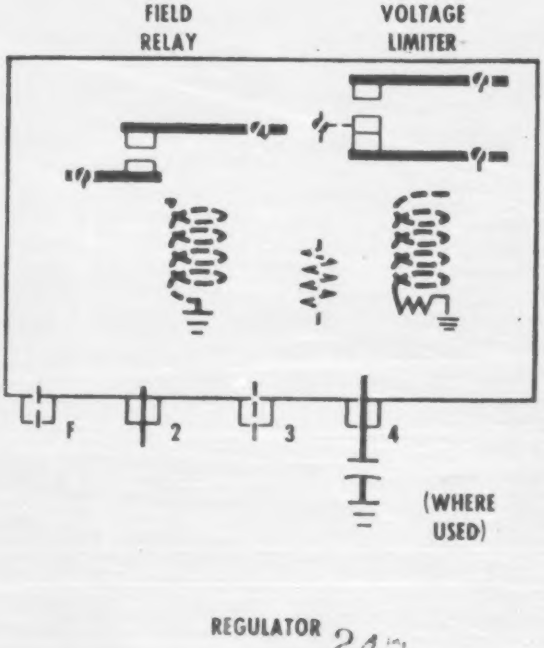
DIRECTIONS: Make the electrical connections, on both diagrames using a pencil.

Indicator lamp without lamp relay


FIELD
RELAY
BAT
ALTERNATOR
JUNCTION BLOCK
BATTERY
IGNITION SWITCH
INDICATOR LAMP
FIELD RELAY
VOLTAGE LIMITER
F
2
3
4
REGULATOR


FIELD
BAT
JUNCTION BLOCK
AMMETER
BATTERY
ALTERNATOR


IGNITION SWITCH


FIELD RELAY
VOLTAGE LIMITER
F
2
3
4
(WHERE USED)
REGULATOR

Instructor's Initials ____________

AUTO MECHANICS

Electrical Competencies - Charging System

No. C-9 Alternator Operation

OBJECTIVE: After you have completed this exercise, you should be able to understand the basic theory of alternator operation.

EXPLANATION: The worksheet provided should be completed while studying the information sheet and reading assignment.

MATERIALS NEEDED:

TOOLS NEEDED:

References	Do
#1. --	1. Study reference assignment
#2. p. 385-389	2. Study information sheet
#3. p. 572-579	3. Complete written worksheet
#4. p. 345-351	4. Check with instructor
#5. p. 174-183	
#6. p. 283-284	
#7. p. 241-245	
#8. --	

Information Sheet # 1

Alternator (AC Generator) Theory of Operation

The dc generator rotates the conductors in a stationary magnetic field. The alternator (ac generator) rotates a magnetic field so that the stationary conductors cut the moving magnetic lines of force.

Let us look at a simple alternator (Fig. 1). In the simple one-loop unit shown, the rotating bar magnet furnishes the moving field. At the top, as the north pole of the bar magnet passes the upper leg of the loop and as the south pole passes the lower leg of the loop, current (electron flows) is induced in the loop in the direction shown by the arrows.

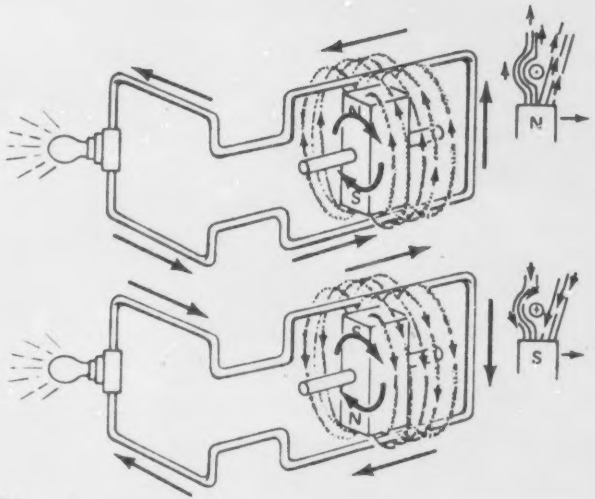


Fig. 1 Simplified alternator consisting of a single stationary loop of wire and a rotating bar magnet. The distortion of moving lines of force around the leg of the loop (conductor) and the direction of current (electron) flow are shown at the right.

At the bottom, the magnet has rotated half a turn so that its south pole is passing the upper leg of the loop and the north pole is passing the lower leg. Now, magnetic lines of force are cut by the two legs in the opposite direction. Thus, as the magnet spins and the two poles alternately pass the two legs of the loop, electrons are pushed first in one direction and then in the other in the loop. Thus alternating current flows.

Two factors will increase the strength of the current (number of electrons) moving in the loop: increasing the strength of the magnetic field and increasing the speed with which the magnetic field moves past the two legs of the loop. Increasing the number of loops is a third method of increasing the current.

In the alternator, both the strength of the magnetic field and the number of loops are increased. Instead of a simple bar magnet, the rotating part of the alternator is made up of two or more pole pieces assembled on a shaft over an electromagnetic winding. The electromagnet is made up of many turns of wire. When current flows in the electromagnet winding, a strong magnetic field is created so that the pointed ends of the two pole pieces become, alternately, north and south poles (Fig. 2). The winding is connected to the battery through a pair of insulated rings that rotate with the shaft and through a pair of stationary brushes that ride on the rings. The two ends of the winding are attached to the rings. The brushes make continuous sliding (or slipping) contact with the slip rings (Fig. 3).

Figure 4 shows the stationary loops of an alternator assembled into a frame. The assembly is called a stator. The loops are interconnected so that the current produced in all loops is added together. Since this current is alternating, it must be converted into direct current. The battery, ignition system, and other electrical components in the automobile all use direct current.

The dc generator actually produces alternating current in its armature windings, but the commutator changes it to direct current. Diodes change the alternating current in the alternator windings to direct current.

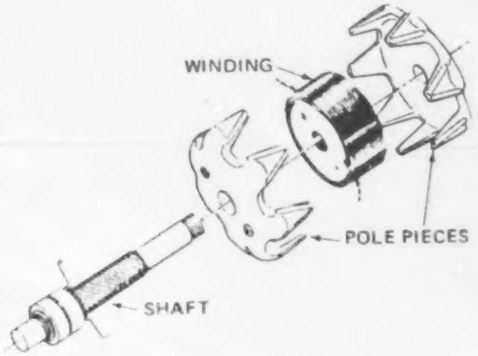


Fig. 2 Rotor of an alternator, in partly disassembled view. (*Delco-Remy Division of General Motors Corporation*)

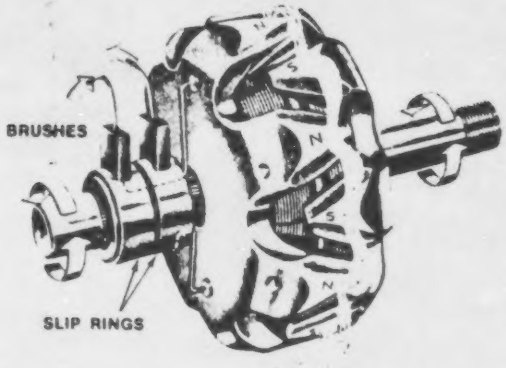


Fig. 3 Rotor of an alternator, showing brushes in place on slip rings. (Delco-Remy Division of General Motors Corporation)

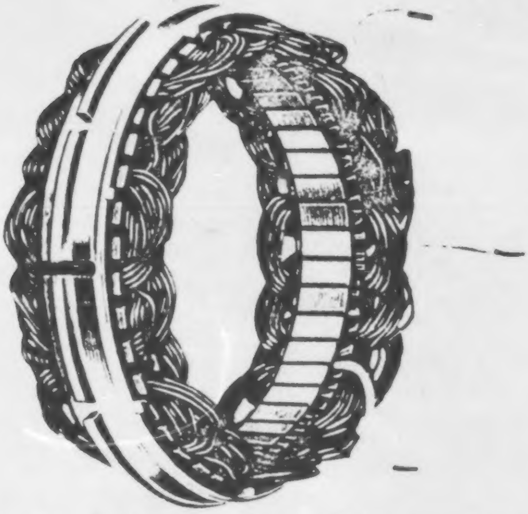


Fig. 4 Stator of an alternator. (Delco-Remy Division of General Motors Corporation)

Alternator (AC Generator) Circuits
We use the terms "alternator" and "ac generator" interchangeably. As we have stated, the alternating current produced in the stator windings is changed to direct current by diodes. This process is called rectification. A set of diodes rectify the alternating current, changing it to direct current. The diode permits current to flow through it in one direction only. Figure 5 shows how four diodes can be used to change ac to dc. The four diodes are numbered 1 to 4 in the illustration. At the left, the current from the ac source follows the conductors shown in heavy, black lines. Diodes 1 and 3 permit the current to flow through them since the current is flowing in the wrong direction for them. However, when the direction of the current has reversed, as shown to the right in Fig. 5 then diodes 2 and 4 will pass the current but diodes 1 and 3 will not.

Three-Phase

The circuit shown in Fig. 5 is termed single-phase because there is only a single ac source. Such a source results in a pulsating current when it is rectified by the diodes. This can be compared to a single-cylinder engine which does not provide a smooth flow of power but rather a series of peaks between which no power is delivered. To provide a smooth flow of current, automotive alternators are three-phase; that is, they are built with three stator circuits which, in effect, give overlapping pulses of alternating current. When these pulses are rectified, a comparatively smooth flow of direct current is obtained.

Delta and Y Stators

The three stator circuits can be connected in two ways, with Y or with delta connections (Fig. 6 and 7). Both operate in a similar manner and are serviced in a similar way.

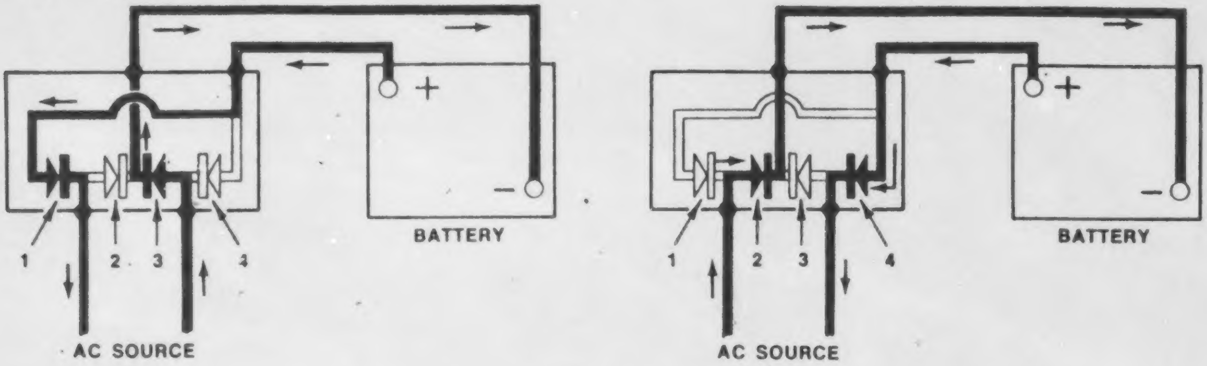


Fig. 5 Four diodes connected to an ac source. The diodes rectify the alternating current and change it to direct current to charge the battery.

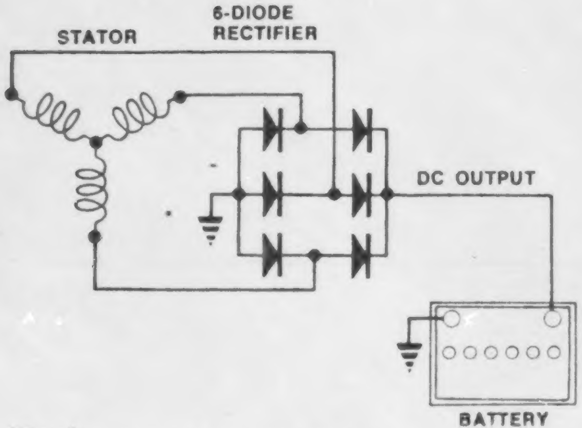


Fig.6 Wiring circuit of an alternator with a six-diode rectifier and a Y-connected stator.

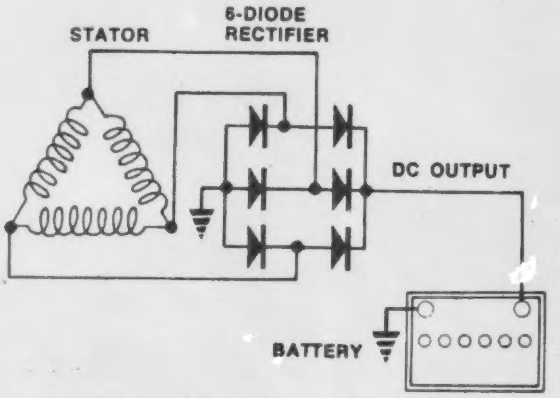


Fig. 7 Wiring circuit of an ac alternator with a six-diode rectifier and a delta-connected stator.

The alternating current generated in the three legs of the stator circuit passes through the six diodes and is converted into direct current. Most automotive alternators use the Y-connected stator circuit.

Electrical Competencies - Charging System

No. C-9 Alternator Operation

Worksheet # 1

Name ____ Date ______________ Grade _________

1. The main difference between an alternator and a generation is that the magnetic field is rotating in an alternator and is stationary in the generator. T or F

2. What three factors could control the amperage output of the alternator?

3. The stationary current conductor on an alternator is called the __________.

4. The rotating magnetic field in an alternator is called the _______________.

5. The electron check value that allows electrical current to flow in one direction onlv is called the ___________________________.

6. Stator winding are connected in one of two ways, _______________ or __________.

7. Draw the symbol of a diode ____________________________________.

8. Alternators do not produce current as well at low speeds as generators. T or F

9. Alternator output is controlled by varying the _______________ current.

10. The ____________________ prevent battery discharge back through the alternator.

AUTO MECHANICS

Electrical Competencies - Charging System

No. C-10 Alternator and Regulator tests on Vehicle

OBJECTIVE: After completing this exercise you will be able to test an Alternator charging system.

EXPLANATION: You will need to use a repair manual for the steps and procedures to test your particular make and model automobile.

MATERIALS NEEDED:

TOOLS NEEDED: Voltmeter, ammeter, carbon pile reheostat

References	Do
#1. ch. 22-p.23-25 #2.-- #3. p. 578-623 #4. p.353-357 #5. p.183-135 #6. p. 290-295 #7. -- #8. -- Automotive Emission Control and Tune-up Procedures IMI 1972 p.183-194 IMI 1975 p.185 & 186	1. Read references assigned 2. Look up factory specifications for your particular make, model and amperage rating for that car, in a repair manual. (Look in the specification section of your repair manual) 3. Look at the service section of your repair manual for the steps and procedures for testing the alternator and regulator. for that make of car. (Check with instructor before actual testing to make sure you have got the correct procedure down) 4. Perform the tests and fill out worksheet. 5. Check with instructor

Electrical Competencies - Charging System

No.C-10 One the Vechicle Testing of Alternators and Regulators

Worksheet # 1

Name ______________________________ Date __________ Grade __________

DIRECTIONS: Fill in the needed information on the blanks provided.

Year and make ____

Name of owner ____

Specifications: __________ Volts ______________ Amps.

at ____________ rpm at __________ °F

(note 10% variance in amperage is allowable)

Procedures for testing your particular make and year.(From the service section of your repair manual.)

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Electrical Competencies - Charging System

No. C-10 On the Vehicle Testing of Alternators and Regulators

Worksheet # 1
Page 2

Name ______________________ Date __________ Grade ________

Directions: Do the following preleminary checks first.

Preleminary Checks	Good	Bad
1. Drive belt tension	________	________
2. Terminal tightness	________	________
3. Corrosion of terminals	________	________
4. Visual conditon of wires	________	________
5. Battery drain test	________	________

NOTE: The battery must be fully charged before accurate voltage regulator tests can be made. The use of a ¼ ohm resistor of 25 watt capacity can be used in series with battery to simulate a fully charged battery.

Directions: Perform the necessary tests, as described in your service manual, to determine if your charging system is operating to specifications.

Record your findings below:

1. Battery voltage (base voltage) ________Volts
2. Alternator no load voltage ________Volts ________Amps.
3. Alternator full load output ________Volts ________Amps.
4. Alternator full fielding (Caution do not exceed 16 Volts) ________Amps.
5. Regulator voltage at ________ rpm and ________ °F with ¼ ohm resistor installed is ________Volts
6. Voltage drop tests (resistance tests)
   a. Insulated circuit specifications ________Volts
   b. Ground circuit specifications ________Volts
   c. Insulated circuit test ________Volts
   d. Ground circuit test ________Volts

   What are your recommedations ______________________________

   ____

Instructor's Initials ________

AUTO MECHANICS

Electrical Competencies - Charging System

No. C-11 Alternator Bench Test

OBJECTIVE:

After the completion of this exercise you will be able to bench test an alternator.

EXPLANATION:

MATERIALS NEEDED:

TOOLS NEEDED:

Ohmmeter or Continuity light

References	Do
#1. Ch. 22, p. 25-28	#1. Study references assigned
#2. --	#2. Refer to service manual for disassembly procedures and disassemble the alternator
#3. --	
#4. p. 357-359	#3. Test components of the alternator using the equipment and procedures listed in repair manual
#5. p. 185-189	
#6. --	#4. Check with instructor
#7. --	
#8. --	

Electrical Competencies- Charging System

No. C-11 Alternator Bench Test

Worksheet #1

Name ________________________________ Date ________________ Grade ______________

Directions: Refer to service manual for disassembly procedures and disassemble the alternator.

Refer to service manual for bench testing procedures. Write those procedures in the space below.

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Discuss these written procedures with instructor before testing of components.

Test the following components.

Rectifier assembly:

Positive diodes	Negative diodes
1. Bad ____ OK ____	1. Bad ____ OK ____
2. Bad ____ OK ____	2. Bad ____ OK ____
3. Bad ____ OK ____	3. Bad ____ OK ____

Test Rotor Assembly:

Ground Test	Continuity Test
1. Bad ____ OK ____	1. Bad ____ OK ____

Electrical Competencies - Charging System
No. C-11 Alternator Bench Test

Worksheet # 1
Page 2

Test Stator:

Ground Tests

1. Bad ____ OK ____

Continuity Tests

1. Bad ____ OK ____

Test Capacitor:

1. Short-Circuited ____ OK ____

Check bearings:

Drive end bearing Bad ____ OK ____

Rectifier end bearing Bad ____ OK ____

Instructor's initials *____________

AUTO MECHANICS

Electrical Competencies - Charging System

No. C-12 Generator and Regulator Tests on Vehicle

OBJECTIVE: After completion of the exercise you will be able to test the charging system on a vehicle equipped with a generator charging system.

EXPLANATION:

MATERIALS NEEDED:

TOOLS NEEDED: Ammeter, Voltmeter, Carbon Pile, Jumper Lead, ¼ Resistor of 25 watt Capacity

References	Do
#1. Ch. 22 p.12-14	1. Study references assigned.
#2. -- #3. p. 544 for Index #4. p. 353- 354 #5. p. 183-190 #6. p.290-295	2. Look up factory specifications for your particular make, model and amperage rating for that car, in a repair manual. (Look in the specification section of your repair manual).
#7. -- #8. --	3. Look at the service section of your repair manual for the steps and procedures for testing the generator and regulator. for that make of car. (Check with instructor before actual testing to make sure you have the correct procedure down on your worksheet).

References	Do
	4. Perform tests and fill remainder of worksheet out. 5. Check with instructor.

Electrical Competencies - Charging System

No. C-12 Generator And Regulator Tests On Vehicle

Worksheet # 1

Name ______________________ Date ____________ Grade __________

Directions: Fill in the needed information on the blanks provided.

Year and make ______________________ ______________________

Name of owner ____

Specifications: ________________Volts ________________Amps.

at ________________rpm at ________________°F

(Note 10% variance in amperage is allowable)

Procedure for testing your particular make and year.

(From the service section of your repair manual.)

____

____

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Electrical Competencies - Charging System

No. C-12 Generator And Regulator Tests On Vehicle

Worksheet # 1
Page 2

Name ______________________________ Date ______________ Grade ______

Directions: Do the following preleminary checks first.

	Good	Bad
1. Drive Belt Tension	________	________
2. Terminal Tightness	________	________
3. Corrosion of Terminals (include battery)	________	________
4. Visual Condition of Wires	________	________
5. Battery Drain Test	________	________

Note: The battery must be fully charged before accurate voltage regulator tests can be made. The use of a ¼ ohm resistor of 25 watt capacity can be used in series with the battery to simulate a fully charged battery.

Directions: Perform the necessary tests, as discribed in your service manual, to determine if your charging system is operating to specifications.

Record your findings below:

1. Battery voltage (base voltage) ________________ Volts
2. Generator no load voltage ________________ Volts
3. Generator full load output ____________ Volts ____________ Amps.
4. Generator full fielding. (Caution do not exceed 16 volts) __________ Amps.
5. Regulator Voltage at __________ rpm and ______________ °F with ¼ ohm resistor installed is ______________ Volts.
6. Voltage drop tests (resistance tests)
    a. Insulated circuit specifications ______________ Voltage drop
    b. Ground circuit specifications ______________ Voltage drop
    c. Insulated circuit test ______________ Voltage drop
    d. Ground circuit test ______________ Voltage drop

What are your recommedations? ____

____

Instructor's Initials ____________

AUTO MECHANICS

Electrical Competencies- Charging System

No.C-13 Generator Bench Test

OBJECTIVE:

After the completion of this exercise you will be able to bench test a generator.

EXPLANATION:

MATERIALS NEEDED:

TOOLS NEEDED:

Continuity light or Ohmmeter

References	Do
#1. Ch. 22 p. 15-18	#1. Study references assigned
#2. --	#2. Refer to service manual for disassembly procedures and disassemble the generator.
#3. p. 551-553	#3. Test components of the generator using the equipment and procedures listed in repair manual, record findings on worksheet.
#4. --	#4. Check with instructor
#5. --	
#6. --	
#7. --	

Electrical Competencies- Charging System

No. C-13 Generator Bench Test

Worksheet #1

Name ____________ ____________ Date ______________ Grade ______________

Directions: Refer to service manual for disassemble procedures and disassemble the generator.

Refer to service manual for bench testing procedures.. Write those procedures in the space below.

Discuss these written procedures with instructor before testing of components.

Test the following components:

	Bad	OK
Test field coils for grounds		
Test armature terminal for ground		
Test insulated brush holder for ground		
Test field coils for open circuit		
Test field coils for short circuit		
Inspect armature		
Test armature		
Test armature for ground		
Test armature for opens		
Test armature for shorts		
Check Commutator		

Instructor's Initials ________

AUTO MECHANICS

Electrical Competencies - Charging System

No. C-14 Diode Removal And Installation

OBJECTIVE: Upon completion of this exercise you should be able to remove and replace an alternator diode.

EXPLANATION: The information sheet acquaints the student with the various means of removing and replacing a diode. The worksheet will apply this knowledge with the assistance of the proper repair manual.

MATERIALS NEEDED: Alternator and repair manual

TOOLS NEEDED: Diode removal and replacement fixtures and related hand tools.

References	Do
#1. --	1. Study references assigned.
#2. --	2. Study information sheet
#3. p. 579-630	3. Complete worksheet
#4. p. 357-362	4. Check with instructor
#5. --	
#6. --	
#7. --	
#8. Ch.22 p. 25-26	

Electrical Competencies - Charging System

No. C-14 Diode Removal And Installation

Information Sheet # 1

Diodes are mounted in three different ways, threaded, pressed, as rectifier assembly that must be replaced as a unit.

Threaded diodes (Fig. 1) are replaced by clipping the flexable leads on each side of the diode lead. Clip the flexible leads as close to the diode lead as possible. See the typical end frame in figure 2. For ease in removing the defective diode, it is recommended that the diode and outside frame be heated in an oven to 150°F., or briefly immersed in hot water just below the boiling point.

Before installing the new diode, lightly coat the threads with silicone grease or light engine oil. With the diode and outside frame at room temperature, install the diode and torque to 160-190 inch-pounds. Since diodes use pipe threads, the depth of penetration may vary from one diode to another.

Place the single diode lead clip furnished in the package over the diode lead, and place the ends of the flexible leads into the clip. (The two identical clips are not used when installing a diode in the outside frame.) Crimp the clip tightly over the flexible leads, and liberally solder the leads to the clip, and the clip to the diode lead. CAUTION: Use only 60% tin, 40% lead solder, or other solder with melting point of 360° F. or above. Do not hold the soldering iron on the leads any longer than necessary, as excessive heat may damage the diode.

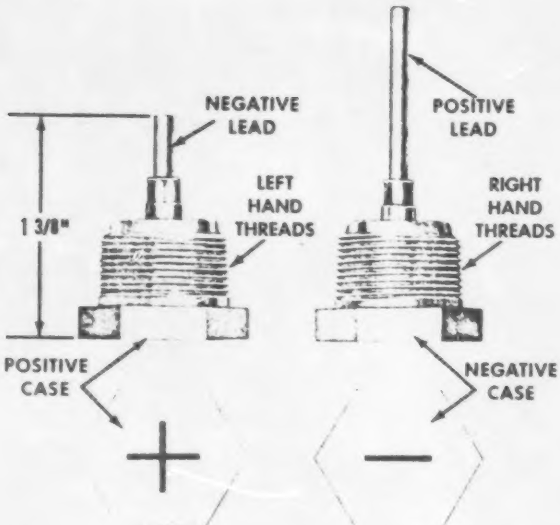

NEGATIVE LEAD
POSITIVE LEAD
LEFT HAND THREADS
RIGHT HAND THREADS
1 3/8"
POSITIVE CASE
NEGATIVE CASE
+
—

Fig. 1 Diodes Showing Polarity Marking On Case.

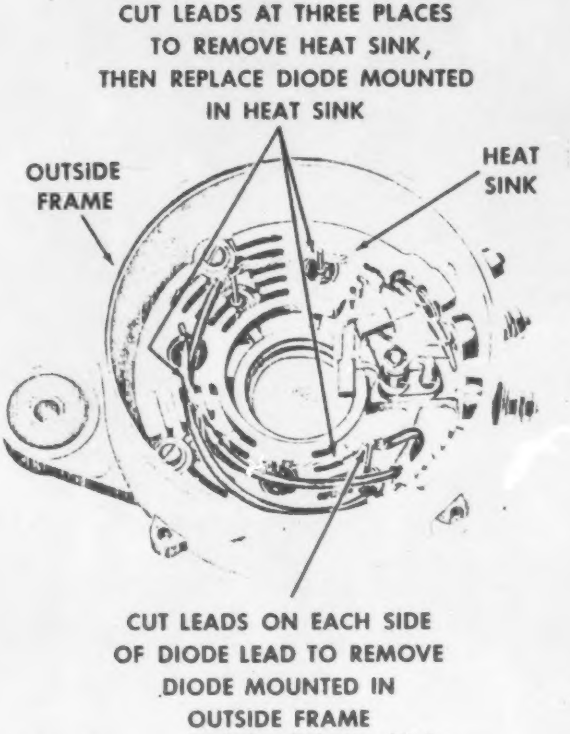

CUT LEADS AT THREE PLACES TO REMOVE HEAT SINK, THEN REPLACE DIODE MOUNTED IN HEAT SINK
OUTSIDE FRAME
HEAT SINK
CUT LEADS ON EACH SIDE OF DIODE LEAD TO REMOVE DIODE MOUNTED IN OUTSIDE FRAME

Fig. 2 Replacing Defective Diodes.

When removing and replacing pressed in diodes a special tool must be used. Clamp it in a vise (Fig. 3). Support the end shield on the clamp anvil under the rectifier to be removed, as shown. Make sure the bore of the tool completely surrounds the diode. Turn the screw to force the diode out. To install a new diode, make sure it is squarely in the mounting hole and use the special installing support (in place of the removing adapter) with the same clamp shown in Fig. 3. Apply pressure with the screw to force the diode in until the collar of the diode bottoms against the casting.

An alternative method in place of the diode installation and removal fixture is the use of special fittings and the shop vice, fig. 4.

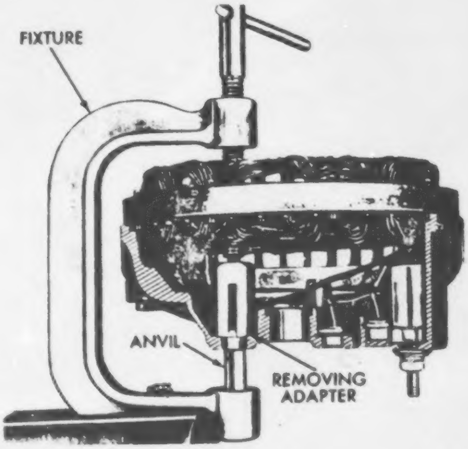


Fig. 3 Removing a diode with a special adaptor. The shield has been cut away in the picture so the adaptor can be seen. (Chrysler-Plymouth Division of Chrysler Motors Corporation.)

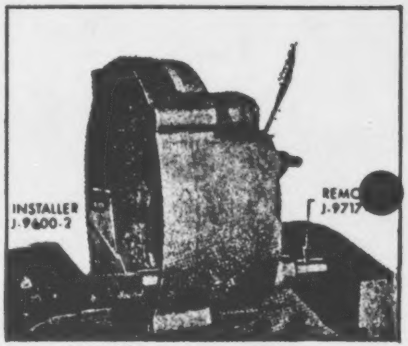


Fig. 4 Installing a diode

CAUTION: Never drive the diode in with a hammer. Any mechanical shock -- even dropping the diode - could ruin it.

Resolder the connections with rosin-core solder. Avoid overheating the diode, as this could ruin it. Quickly cool the soldered connection with a clean dampened with water.

To simplify diode replacement, many late-model alternators have rectifier bridges or diode plates that contain three or six diodes in one assembly. If one or more diodes is bad, the entire bridge or plate is replaced without the need for cutting and soldering diode leads.

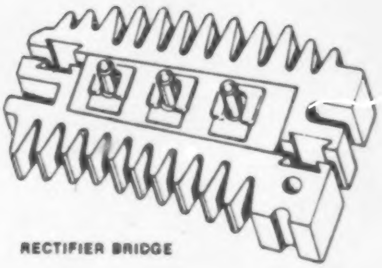

RECTIFIER BRIDGE

Fig. 5

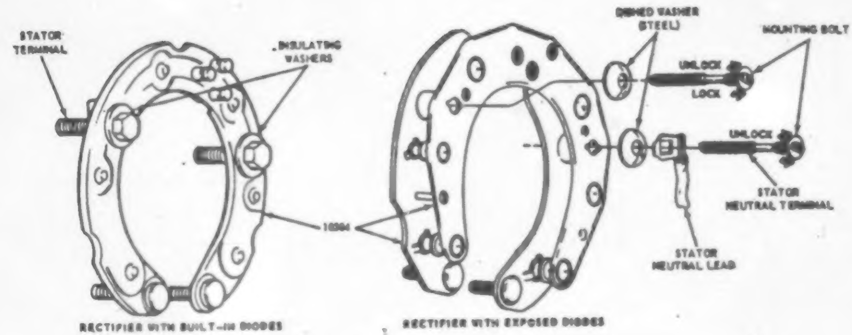

STATOR TERMINAL
INSULATING WASHERS
DISHED WASHER (STEEL)
MOUNTING BOLT
UNLOCK
LOCK
UNLOCK
STATOR NEUTRAL TERMINAL
STATOR NEUTRAL LEAD
RECTIFIER WITH BUILT-IN DIODES
RECTIFIER WITH EXPOSED DIODES

Fig. 6 Rectifier assembly

Electrical Competencies - Charging System

No. C-14 Removing And Replacing Diode

Worksheet # 1

Name ______________________ Date ____________ Grade ____________

DIRECTIONS: Write the steps and procedures for removing and replacing a diode for the alternator that you are working on. (From service section of your repair manual.)

Make of Alternator ______________________ Model Number ________________

Amperage Output ____________________

Steps And Procedures ____

Check with instructor before removing diode.

Remove Diode

Replace Diode Instructor's Initials ___________

AUTO MECHANICS

Electrical Competencies- Charging Systems

No. C-15 Changing Pulley

OBJECTIVE:

After the completion of this exercise you will be able to change a pulley on a generator or alternator on a particular charging system.

EXPLANATION: Due to the various ways drive pulleys are attached, it is very important to follow the repair manual for that particular unit.

MATERIALS NEEDED:

Repair Manual

TOOLS NEEDED:

Tools needed vary from vehicle to vehicle, refer to service section of your repair manual for needed tools.

References	Do
#1. Ch. 22, p.15	#1. Study references assigned.
#2. --	#2. Look in the service section of your repair manual for the steps and procedures for changing a pulley on your particular generator or alternator.
#3. p. 554, 595	#3. Write those steps and procedures down on your worksheet.
#4. p. 357	#4. Check with instructor before removing pulley.
#5. --	#5. Remove pulley.
#6. --	#6. Check with instructor.
#7. --	
#8. --	

Electrical Competencies- Charging System

No. C-15 Changing Pulley

Worksheet #1

Name ______________________________ Date __________________ Grade ____________

Directions: Write the steps and procedures for removing the pulley in the space below. (From the service section of your repair manual).

____

____

____

____

____

____

Check with instructor before removing pulley.

Then proceed with the steps and procedures to remove pulley.

Instructor's Initials __________

AUTO MECHANICS

Electrical Competencies - Charging System

No. C-16 Bearing R & R

OBJECTIVE:

After the completion of this exercise you will be able to replace the bearings in an alternator or generator of a particular make and model of a automobile.

EXPLANATION: Due to the various types of alternators and generators, and the means of removing and replacing bearings, it is very important to follow the repair manual for that particular make, year and model.

MATERIALS NEEDED:

Repair Manual

TOOLS NEEDED:

Tools needed vary from vehicle to vehicle, refer to service section of your repair manual for needed tools.

References	Do
#1. --	#1. Look in the service section of your repair manual for the steps and procedures for replacement of the bearings in your particular generator or alternator.
#2. --	#2. Write those steps and procedures down on your worksheet.
#3. --	#3. Check with instructor before removal and replacement of bearings.
#4. --	#4. R & R bearing
#5. --	#5. Check with instructor.
#6. --	
#7. --	
#8. --	

Electrical Competencies- Charging Systems

No. C-16 Bearing R & R

Worksheet #1

Name ______________________________ Date ___________________ Grade _______________

Type of Generator or Alternator ____

Directions: Write the steps and procedures for bearing R & R, for your particular make and model, on the space provided below. (From the service section of your repair manual).

____

____

____

____

____

____

Check with instructor before proceding work on bearing R & R.

Then proceed with the steps and procedures to R & R bearing.

Check with instructor.

Instructor's Initials __________

AUTO MECHANICS

Electrical Competencies- Charging System

No. C-17 Brush Replacement

OBJECTIVE:

After the completion of this exercise you will be able to replace the brushes in either a generator or alternator.

EXPLANATION: It is suggested that you replace the brushes in both a generator and alternator as there are inherent differences.

MATERIALS NEEDED:

Repair Manual

TOOLS NEEDED:

Tools needed vary from vehicle to vehicle, refer to service section of your repair manual for needed tools.

References	Do
#1. Ch. 22, p. 14-15, 26	1. Study references assigned.
#2. --	2. Refer to service manual for the steps
#3. p. 549-554, 630	and procedures for brush R & R
#4. --	3. Write those steps in the space
#5. --	provided on worksheet.
#6. --	4. Check with instructor before R & R
#7. --	5. R & R Brushes
#8. --	6. Check with instructor

Electrical Competencies- Charging System

No. C-17 Brush Replacement

Worksheet #1

Name ______________________ Date ______________ Grade ____________

Type of Generator or Alternator ______________________________

Directions: Write the steps and procedures for brush replacement, for your particular make and model, on the space provided below. (From the service section of your repair manual.

Check with instructor before proceding work on brush replacement.

Then proceed with the steps and procedures of brush replacement.

Check with instructor.

Instructor's Initials __________

AUTO MECHANICS

Electrical Competencies- Charging System

No. C-18 Reface Generator Commutator

OBJECTIVE: After the completion of this exercise you will be able to reface the commutator.

EXPLANATION: Commutator bars must be refaced when they have become out of round or when the surfaces have irregularities or groves. Failure to do so results in poor conductivity and rapid brush wear.

MATERIALS NEEDED: Generator armature in need of service.
Information sheet and service manual.

TOOLS NEEDED: Armature lathe and related hand tools.

References	Do
#1. Ch. 22 p. 18	#1. Study reference
#2. --	#2. Refer to Electrical Competencies-Cranking System, D-9, Disassemble, Test, Repair and Assemble Cranking Motors, for information sheets on turning commutator.
#3. p. 551	#3. Refer to the armature lathe manual for the operating instructions on your particular machine.
#4. --	#4. Check with instructor before doing any operation of the lathe for a demonstration on the use of the armature lathe.
#5. --	#5. Complete the worksheet.
#6. --	#6. Check with instructor.
#7. --	
#8. --	

Electrical Competencies- Charging System

No. C-18 Reface Generator Commutator

Worksheet #1

Name ______________________ Date ____________ Grade ____________

NOTE: All generators must have the mica undercut.

Make of Generator __________________ Year ______________

Make and Model of Armature lathe ______________________________

	Not Acceptable	OK
Reface Armature	________	________
Undercutting of Mica	________	________

Instructor's Initials ________

AUTO MECHANICS

Electrical Competencies - Charging System

No. C-19 R & R Alternator

OBJECTIVE: After the completion of this exercise you will be able to remove and replace an alternator.

EXPLANATION: A good understanding of the precautions is essential to protect the electrical system.

MATERIALS NEEDED: Repair manual

TOOLS NEEDED: Tools needed will be stated in the service section of your repair manual.

References	Do
#1. Ch. 22 p. 22	1. Study references assigned.
#2. --	2. Review Electrical Competencies -
#3. --	Charging System No. C-1 Safety Information
#4. p.357	Sheet # 1.
#5. --	3. Fill out worksheet before R & R
#6. --	of alternator, check with instructor.
#7. --	4. Check with instructor.
#8. --	

Electrical Competencies - Charging System

No. C-19 R & R Alternator

Worksheet # 1

Name ______________________________ Date ______________ Grade ______

DIRECTIONS: Refer to the service section of your repair manual for the steps and procedures for R & R the alternator for the vehicle you are working on.

Write the steps and procedures for R & R of the Alternator in the space provided below.

____

____

____

____

____

Check with instructor before R & R the alternator.

Instructor's Initials ____________

AUTO MECHANICS

Electrical Competencies - Charging System

No. C-20 R & R Regulator

OBJECTIVE: After the completion of this exercise you will be able to remove and replace a alternator

EXPLANATION: Due to the various types of regulators and service precautions, it is very important to follow the repair manual for the correct make, model, etc.

MATERIALS NEEDED: Repair manual

TOOLS NEEDED: Tools needed with be stated in the service section of your repair manual.

References	Do
#1. Ch. 22 p. 41	1 Study references assigned.
#2. --	2. Look in the service section of your
#3. --	repair manual for the steps and procedures
#4. --	for R & R of your regulator.
#5. --	3. Write those steps and procedures
#6. --	down on your worksheet.
#7. --	4. Check with instructor before
#8. --	R & R of regulator.
	5. Check with instructor.

Electrical Competencies - Charging System

No. C-20 R & R Regulator

Worksheet # 1

Name ______________________________ Date ______ ______ Grade __________

Type of Regulator ______________________________

DIRECTIONS: Write the steps and procedures for regulator R & R, for your particular make and mode, on the space provided below. (From the service section of your repair manual.)

____

____

____

____

____

____

Check with instructor before proceding R & R of Regulator.

Then proceed with the ateps and procedures to R & R regulator.

Check with instructor.

Instructor's Initials __________

AUTO MECHANICS

Electrical Competencies - Charging System

No. C-21 R & R Drive Belt

OBJECTIVE: After you have completed this exercise, you should be able to properly remove and replace a charging system drive belt to factory specifications.

EXPLANATION: The drive belt information sheet will cover general belt R & R information, which will aid the student in servicing belts to factory specifications following the worksheet provided.

MATERIALS NEEDED: Drive belt
Repair manual and specifications

TOOLS NEEDED:
Belt tension gage, pry bar, related hand tools

References	Do
#1. --	1. Study reference assignment.
#2. --	2. Study information sheet.
#3. --	3. Complete worksheet
#4. --	4. Check with instructor
#5. --	
#6. --	
#7. --	
#8. --	

Electrical Competencies - Charging System

No. C-21 Drive Belt Removal And Replacement

Information Sheet # 1

Drive Belts

Fan belts and other driving belts should be replaced when they begin to show wear. Belts are designed to contact the sides of their pulleys and should not touch the bottom of the pulley groove.

The sides of the pulley should have a polished appearance because of belt contact but if the bottom of the groove is polished it indicates that the felt does not fit properly or is much too tight. To be on the safe side a new belt should be installed.

A belt should be replaced when it becomes frayed. Before installing the new belt examine the sides of the pulleys for rough spots. If any are found, replace the pulley or smooth it up with fine emery cloth. A pulley with a broken flange should be discarded.

Pulleys at all times should be kept free of oil and grease because lubricants may cause the belt to slip, may pick up dirt that will soon fray the belt or may ruin the belt by softening the rubber used in its construction.

Belt Adjustments

Fig. 1 illustrates the most common fan-generator-water pump belt arrangement, while Fig. 2 shows a typical belt set-up when air conditioning and power steering are involved. The adjustment links and slots shown are in general use on most cars.

Precise adjustment of drive belts is a must. Loose adjustment of fan-generator belts may cause overheating and low generator output; slippage of the power steering pump belt may not provide adequate oil pressure, and slippage of the air conditioner compressor belt may not provide enough pressure for proper operation of the system. Too tight adjustment wear belts prematurely and causes early failure of shafts and bearings in the driven units.

Car manufacturers stress the importance of proper belt adjustments and almost all of them recommend the use of a belt strand tension gauge, Fig. 2. The gauge is placed midway on the belt as shown. Then the belt is adjusted until the proper tension is indicated on the gauge. In the example shown, the fan-generator belt is adjusted to 60 lbs, the power steering belt to 80 lbs, and the compressor belt to 72 lbs.

If such a gauge is not available, general practice is to adjust a belt of ordinary length so it has a deflection of ½" at its midway point; longer belts would require a greater deflection, say 3/4" to 1".

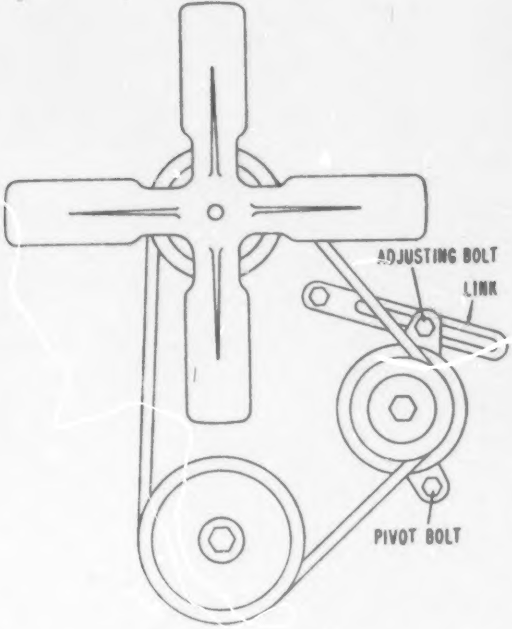

ADJUSTING BOLT
LINK
PIVOT BOLT

Fig. 1 *Generator supported by pivot bolt below and link above. Loosen pivot bolt and link nut. Move generator outward. When fan belt tension is correct, tighten link nut and pivot bolt*

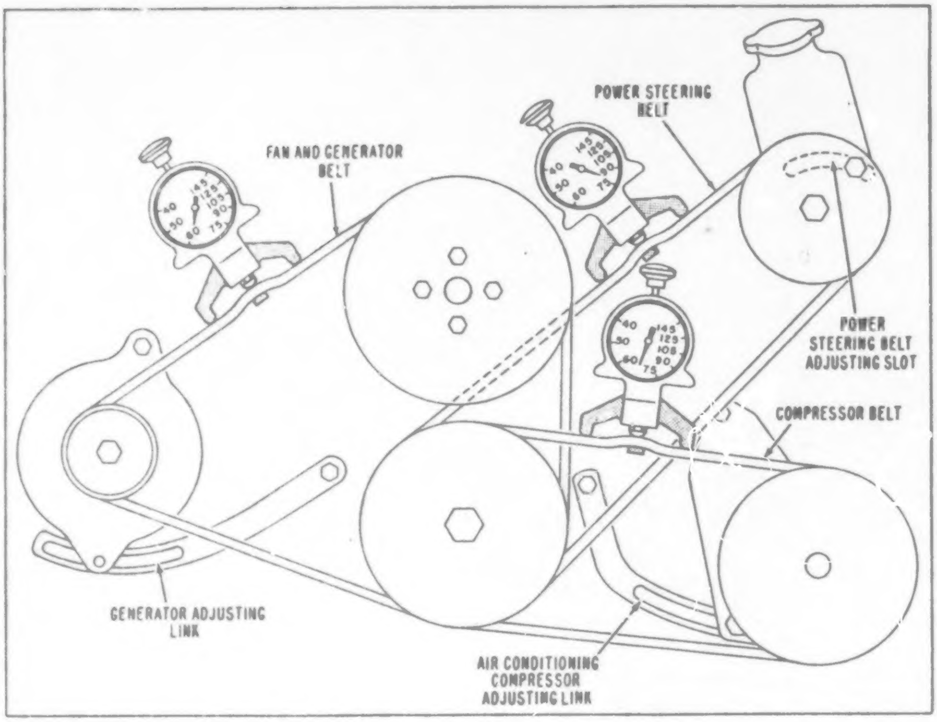

FAN AND GENERATOR BELT
POWER STEERING BELT
POWER STEERING BELT ADJUSTING SLOT
COMPRESSOR BELT
GENERATOR ADJUSTING LINK
AIR CONDITIONING COMPRESSOR ADJUSTING LINK
40
50
60
75
90
105
125
145

Fig. 2 *Showing use of belt strand tension gauge*

Electrical Competencies - Charging System

No. C-21 R & R Drive Belt

Worksheet # 1

Name ______________________________ Date ____________ Grade ____________

DIRECTIONS: Write the steps and procedures for removing and replacing the drive belt, on your particular make and model, on the lines provided below. (From the service section of your repair manual.)

____

____

____

Check with instructor before R & R the drive belt.

R & R drive belt

Check with instructor

Instructor's Initials __________

Electrical Competencies - Charging System

No. C Final Test - Charging System

Name ______________________________ Date ____________ Grade __________

1. Three things must be present to produce electrical current.

   A. Voltage, resistance, and magnetic force
   B. Resistance, magnetic force, and motion
   C. Conductor, motion, and magnetic force
   D. Motion, magnetic force, and voltage

2. The basic generator components consist of

   A. Bendix, field frame, brushes, and rotor
   B. Armature, pole shoes, field coils, and brushes
   C. Field coils, relief value, rotor, and pole shoes
   D. Brushes, ring gear, armature, and field coils

3. The typical regulator for a D C system includes a cutout relay, a

   A. Voltage regulator, and a transistor control
   B. Voltage regulator, and current regulator
   C. Field relay, and an output regulator
   D. Transistor control and a field relay

4. Generator output is controlled by regulating the amount of

   A. Counter electromotive force
   B. Armature windings
   C. Field voltage output
   D. Field current

5. The two most common types of generator field circuits are the

   A. A & B circuits
   B. C & D circuits
   C. Third brush & C type
   D. Bocking field & A type

6. The process by which full generator output is produced is known as

   A. W.O.T. (wide open throttle)
   B. Full fielding
   C. Red lining
   D. Maxing E.M.F. (electromotive force)

7. The process known as polarizing is accomplished by

   A. Cooling the ground side of the field coils
   B. Monentarily touching a hot wire to the output terminal
   C. Passing a current through the field coils in the proper direction
   D. Monentarily rotating the generator in the proper direction

8. When checking the generator - regulator system, a charged battery and a low charging rate means that the

   A. Regulator requires adjustment
   B. System is probably OK.
   C. Generator is unable to produce a high charging rate.

9. When checking the generator - regulator system, a charged battery and a high charging rate means that

   A. The system is probably OK.
   B. Further checking should be done
   C. The relay is not opening its points

10. When checking the generator - regulator system, a discharged battery and a high charging rate means that

   A. Further checking should be done
   B. The regulator requires adjustment
   C. The system is operating normally

11. When checking a charging system problem one of the first steps is to

   A. Check drive belt and connections
   B. Adjust regulator
   C. Replace generator with known good unit
   D. Replace the battery

12. The making and breaking of the connection between the generator and the battery in a D C charging circuit is accomplished by the

   A. Cutout relay
   B. Current regulator
   C. Field relay
   D. Ignition switches

13. Voltage drop checks are performed on the charging system to detect

   A. Bad diodes
   B. Worn brushes
   C. Voltage regulator settings
   D. Poor connections or defective wires

14. When a defective charging system is full fielded it begins to produce current within specifications, the component most likely at fault would be

   A. Regulator
   B. Drive belt
   C. Field coil
   D. Brushes

15. When bench testing an armature it should be tested for

    A. Grounds
    B. Shorts
    C. Coil balance (continuity)
    D. All of the above

16. The instrument used for testing armatures is called the

    A. Rotor
    B. Growler
    C. Volt - ohmmeter
    D. Ammeter

17. When testing brushes and holders, one should be grounded and the other insulated.

    A. True
    B. False

18. Field coils are tested for continuity, grounds, and shorts.

    A. True
    B. False

19. The same general charging systems tests for D C circuits will apply to A C circuits.

    A. True
    B. False

20. On an A C circuit reverse flow of current from the battery to the alternator is prevented by the

    A. Cutout relay
    B. Voltage limiter
    C. Diodes
    D. Stator windings

21. The main components of the alternator are the

    A. Armature, stator windings, rotor, and brushes
    B. Stator windings, commutators, diodes, and brushes
    C. Brushes, rotor, stator windings, and diodes
    D. Field relay, armature, diodes and rotor

22. The unit in the alternator regulator that is also common to the generator regulator is the

    A. Field relay
    B. Voltage regulator
    C. Cutout relay
    D. Current limiter

23. The three basic components to be checked in an A C generator are the

    A. Armature, rotor, and transistors
    B. Stator, field windings, and armature
    C. Stator, rotor, and diodes
    D. Rotor, armature, and field windings

24. A good diode

    A. Passes current in both directions
    B. Severely restricts the amount of current
    C. Has high ohm readings in both directions
    D. Has one high and one low ohm reading

25. Stator windings are checked for grounds, shorts, and continuity

    A. True
    B. False

26. Rotors are checked for grounds, shorts, and continuity

    A. True
    B. False

27. Standard procedure for removing and replacing a diode is with a hammer

    A. True
    B. False

28. Alternators do not need polarization

    A. True
    B. False

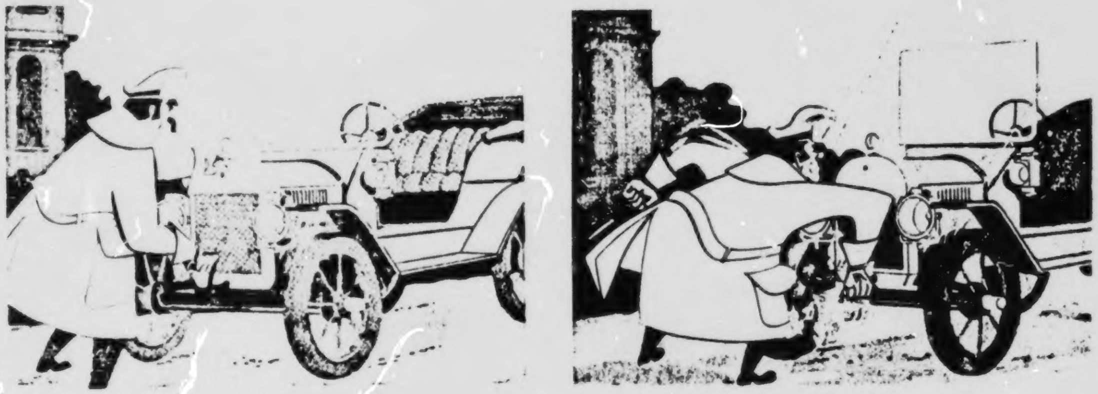
29. Standard procedure when removing and replacing an alternator is to remove battery ground cable first and replace battery ground cable last.

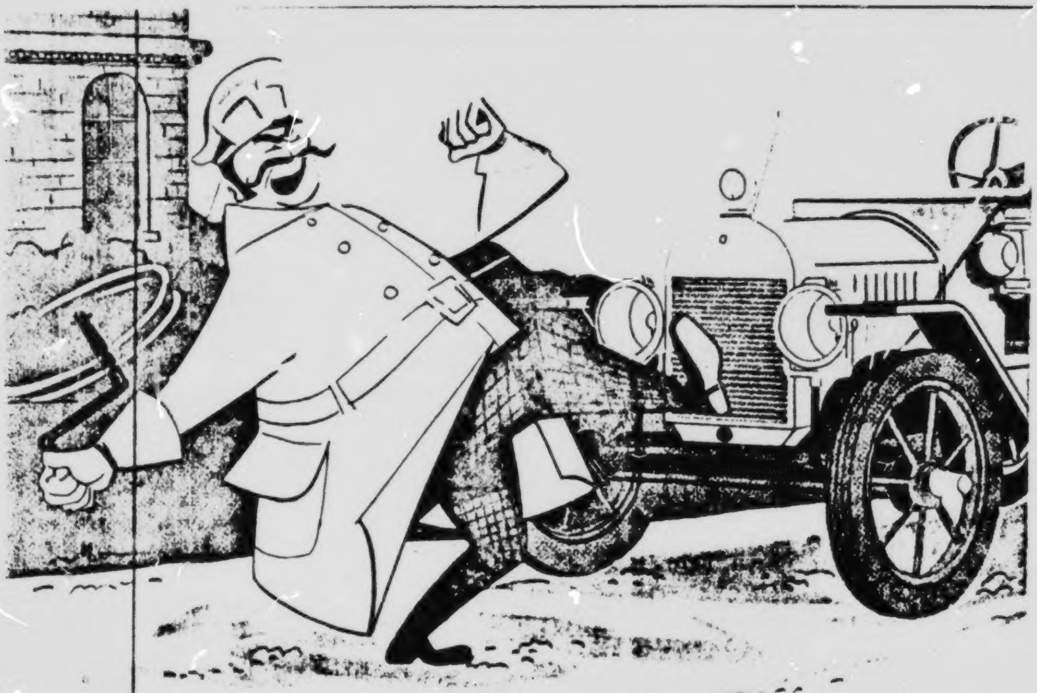
    A. True
    B. False

30. When a higher than specification voltage condition exits, the alternator is usually at fault.

    A. True
    B. False

The Cranking Circuit





REFERENCE

The texts chosen were selected because they are in current use by the instructors who compiled this manual. You should have a copy of at least one in your shop.

The text books are to be used as references for each exercise in this book. For each exercise you will find a number followed by page numbers. Look up the book number on this list and the page numbers will corresponds to the exercise you are working. For example if you find 5. 103-211 in the reference section you would check this reference list and find that book No. 5 is Auto Mechanics by H. E. Ellinger. In that book, pages 103-211 will apply to the exercise you are working.

TEXT	AUTHOR	PUBLISHER
1. Auto Service and Repair 1975	Stockel	Goodheart - Willcox
2. Auto Mechanics Fundamentals 1974	Stockel	Goodheart - Willcox
3. Motor Auto Engines and Electrical Systems 1975	Hearst Corporation	Motor
4. Automotive Encyclopedia 1975	Tobotdt - Johnson	Goodheart - Willcox
5. Auto Mechanics Second Edition	Ellinger	Prentice - Hall
6. Automotive Mechanics	Crouse	McGraw - Hill
7. The Auto Book	Crouse	McGraw - Hill
8. Automotive Chassis And Accessory Circuits	Brezcha/Samuels	Prentice - Hall

Auto Mechanic's
Cranking System
No. D - Index

D 1 -- Safety

D 2 -- Components and Circuit Identification

D 3 -- Amperage Draw Test

D 4 -- Insulated and Ground Test

D 5 -- Cranking Voltage Test

D 6 -- Cranking Control Circuit Test

D 7 -- R & R Solenoid

D 8 -- R & R Starter

D 9 -- Disassemble, Test, Repair and Assemble Cranking Motor

D 10 -- No Load Test

D 11 -- Troubleshooting the Cranking System

SCHOOL ____________________ STUDENT ____________________

INSTRUCTOR ____________________ YEAR GRAD ____________________

AUTOMOTIVE ELECTRICAL COMPETENCIES-CRANKING SYSTEM

	COMPETENCY	JR	M	C	SR	M	C	VOC	M	C	IND	M	C
D-1	Safety												
D-2	Components and Circuit Identification												
D-3	Amperage Draw Test												
D-4	Insulated and Ground Test												
D-5	Cranking Voltage Test												
D-6	Cranking Control Circuit Test												
D-7	R & R Solenoid												
D-8	R & R Starter												
D-9	Disassemble, Test, Repair And Assemble Cranking Motor												
D-10	No Load Test												
1	Troubleshooting The Cranking System												
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													

THIS COMPETENCY SHEET LISTS ALL THE SKILLS REQUIRED FOR THIS BOOK. THEY ARE LISTED IN A LOGICAL ORDER ALTHOUGH THERE IS NO FIXED SEQUENCE FOR COMPLETING THE EXERCISES. EACH HEADING HAS A COLUMN TO ITS RIGHT WITH SPACES TO ALLOW GRADING AFTER YOU COMPLETE THAT EXERCISE. WE HAVE TAKEN INTO ACCOUNT THAT NOT EVERY EXERCISE WILL BE COMPLETED THE FIRST YEAR. THEREFORE, WE HAVE SPOTS FOR JUNIOR, SENIOR, VOCATIONAL AND INDUSTRY. AS YOU COMPLETE A PARTICULAR COMPETENCY, (OR TASK) YOU WILL BE GRADED ACCORDING TO THE SCALE AT THE BOTTOM OF THIS SHEET. ALSO, IF THERE ARE ANY MATH OR COMMUNICATION SKILLS REQUIRED THEY CAN ALSO BE GRADED USING THE CODE N, 1, 2, OR 3. THE DATE OF COMPLETION WILL BE ENTERED UNDER THE APPROPRIATE YEAR AND COMPETENCY. YOU WILL HAVE THE OPPORTUNITY TO UPGRADE ANY ONE OF THESE SKILLS AT ANY TIME AFTER YOU FIRST COMPLETE THE TASK AND HAVE THE NEW RATING ENTERED ON THIS SHEET.

RATING SCALE

N = No opportunity to perform
1 = Completed exercise with close supervision
2 = Completed exercise with little supervision
3 = Completed exercise without supervision

M = Math
C = Communications

SCHOOL ______________________ STUDENT ______________________

INSTRUCTOR ______________________ YEAR GRAD ______________________

AUTOMOTIVE ELECTRICAL COMPETENCIES-CRANKING SYSTEM

	COMPETENCY	JR	M	C	SR	M	C	VOC	M	C	IND	M	C
D-1	Safety												
D-2	Components and Circuit Identification												
D-3	Amperage Draw Test												
D-4	Insulated and Ground Test												
D-5	Cranking Voltage Test												
D-6	Cranking Control Circuit Test												
D-7	R&R Solenoid												
D-8	R&R Starter												
D-9	Disassemble, Test, Repair And Assemble Cranking Motor												
D-10	No Load Test												
D-11	Troubleshooting The Cranking System												
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													

RATING SCALE

N = No opportunity to perform
1 = Completed exercise with close supervision
2 = Completed exercise with little supervision
3 = Completed exercise without supervision

M = Math
C = Communications

AUTO MECHANICS

Electrical Competencies - Cranking System

No.D-1 Safety

OBJECTIVE: After you have completed this exercise you will be able to safely perform cranking system tests and servicing.

EXPLANATION: You will be expected to pass a safety test with 100% accuracy prior to working on the cranking system.

MATERIALS NEEDED:

TOOLS NEEDED:

References	Do
#1.	1. Study reference assignment
#2.	2. Study information sheets
#3.	3. Complete the written test
#4.	4. Check with instructor
#5.	5. Give safety test to instructor
#6.	
#7.	
#8.	

No. D-1 Safety Information Sheet #1

In order to fullfill this competency it is required that you go through and understand the information sheets on battery safety. There will be some questions on the safety test that will refer to those sheets.

In addition to the battery safety is is extremely important to be sure the car is properly supported using the safety equipment available. When using a hoist make sure the hoist is properly positioned under the car and the safety leg is in operation. The hoist should be positioned under the cars frame. When using a jack, follow safety instructions on the jack and position the jack to lift the car in a solid position. Once car is in the air, always use safety jack stands.

When working on the cranking system it is important to remove all jewelry (rings, watches, etc.).

When working on the cranking system never use the battery for a place to lay tools.

Electrical Competencies - Cranking System

No. D-1 Safety

Test # 1

Name ____ Date ___________________ Grade ___________

1. Always remove ___________ cable from battery before removing cranking motor.

2. Be sure vehicle is properly _________ on hoist or jack stands before removing cranking motor.

3. Always wear ____________ ______________ when working in the shop.

4. The negative post is the _____________ (smaller- larger) post on the battery.

5. The possibility of electrical burns caused by arcing between a battery terminal remove____________and_________________ before servicing a battery.

6. The negative battery terminal (post) may be indentified by:
   - A. Being marked -
   - B. Smaller in size
   - C. Being painted green
   - D. Being marked minus
   - E. Answer A, B, C
   - F. All of the above

Instructor's Initials _____________

AUTO MECHANICS

Electrical Competencies - Cranking System

No. D-2 Components and Circuit Idenification

OBJECTIVE: After completion of this exercise you should be able to identify the components of an automobile starting system, explain their function, and draw the current flow within the system.

EXPLANATION: In order to diagnose problems in the cranking system you will need to know what components are in the system, what their functions are and how they are electrically connected together.

MATERIALS NEEDED:

TOOLS NEEDED:

References	Do
#1.Ch. 22 p. 42	1. Read assigned references
#2.p.391-397	2. Read information sheets
#3.p617-620, 647-652	3. Complete written worksheet
#4.p.381-389	4. Check with instructor
#5.p.162-169	5. Complete the test
#6.p.265-272	6. Check with instructor
#7.	
#8.	

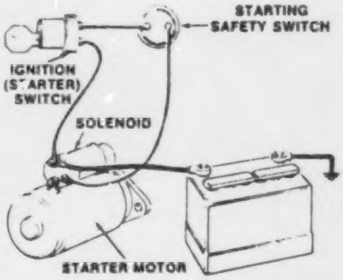
Electrical Compentencies - Cranking System

No. D-2 Components and Circuit Idenification

Information Sheet # 1

The Basic Starting System

The starting system consists of the battery, the starter switch (part of the ignition switch), the starting safety switch, a vacuum switch (when used), the starter relay or solenoid, the starter motor and drive, and the circuit wiring. In some systems the starter relay and solenoid are one unit mounted on the starter motor. Other systems have only a relay, mounted on the chassis.

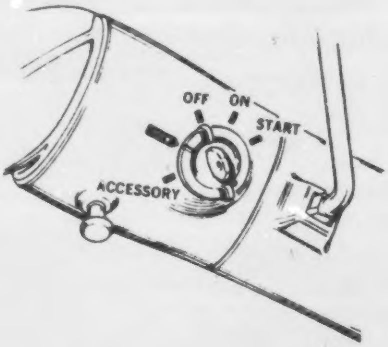


There are two circuits in the starting system: the starter control circuit, and the starter motor circuit. The control circuit consists of the starter switch, the safety switch, and the starter relay or solenoid winding. The starter motor circuit consists of the starter motor, the relay or solenoid contacts, and heavy wiring.

The Ignition Switch

The ignition switch normally has at least four positions:

1. Accessories
2. Off
3. On
4. Start



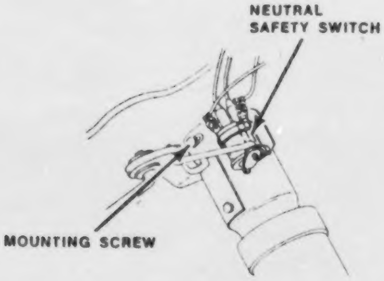
Switches on late-model cars also have a Lock position to lock the steering. All positions are detented except the Start position. When the ignition key is turned to Start and released, it will return to the On position. The Start position is the actual starter switch part of the ignition switch. It applies battery voltage to the starter relay or solenoid and to the ignition system simultaneoulsy.

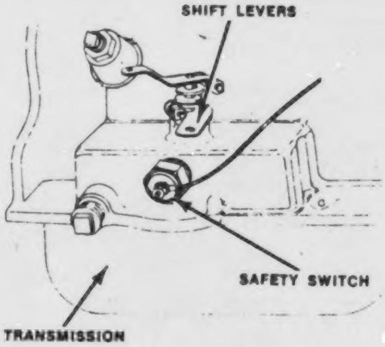
The Starting Safety Switch

All cars with automatic transmissions and many late-model cars with manual transmissions have a safety switch to prevent the engine from starting when the transmission is engaged. This starting safety switch is often called the "neutral switch." The most common type of safety switch used with automatic transmissions is mounted on the steering column, either under the dash or on the engine side of the firewall. Switches of this type are adjusted by loosening the switch mounting screws and positioning the switch so it will close only when the gearshift lever is in Neutral or Park. Cars with automatic transmissions that have floormounted shift levers usually have starting safety switches mounted on the transmission or under the console. These switches are also closed when the shift linkage is in Neutral or Park.

Chrysler Corporation and AMC cars with Torque Flite and Torque Command transmissions have a starting safety switch mounted on the transmission. This type of switch is adjusted by centering a cam on the shift linkage so the switch will close only in Neutral or Park.

Many late-model cars with ignition switch locks that lock the steering and the transmission shift linkage employ a mechanical interlock between the starting circuit and the transmission linkage. This type of starting safety device is not an electrical switch but a mechanical lock that prevents the key from being turned to the Start position unless the transmission selector is in Neutral or Park.



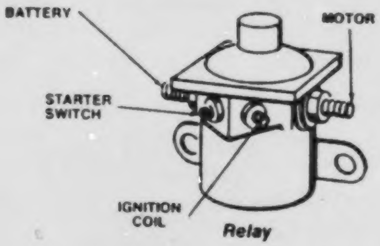


Some late-model cars with manual transmissions also have starting safety switches. These switches are usually actuated by the clutch linkage and are often called "clutch start switches." They are closed by depressing the clutch pedal so that the engine cannot be started unless the clutch is disengaged.

The Vacuum Switch

Some starter control circuits incorporate a carburetor-type vacuum switch. It is connected to the intake manifold and to the carburetor throttle linkage. Depressing the accelerator closes the switch contacts so that the starter circuit is complete through the switch. As soon as the engine starts, intake manifold vacuum opens the vacuum switch so that cranking stops.

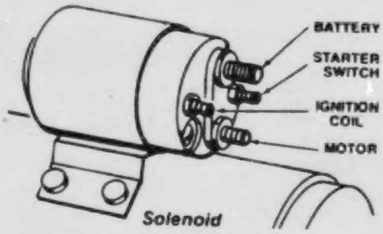
The Starter Relay



Relay

The starter relay is an electromagnetic switch that connects the starter motor directly to the battery for starting. It provides a direct circuit of heavy-gauge wiring for the high current draw of the starter motor. The relay is operated by the starter control circuit,which uses very little current. This type of simple relay is used with a Bendix-drive or a movable pole shoe starter. The relay is mounted on the vehicle chassis, away from the starter.

The Starter Solenoid



Solenoid

The starter solenoid is an electromagnetic device that incorporates a starter relay and mechanical linkage to engage the starter drive. The heavy solenoid coil is mounted on a plunger that is connected to a shift lever. When the solenoid is energized by the control circuit, the solenoid shifts the starter drive pinion into mesh with the flywheel ring gear. Further plunger movement then closes the starter motor circuit contacts to supply current to the motor. The solenoid is mounted on top of the starter motor.

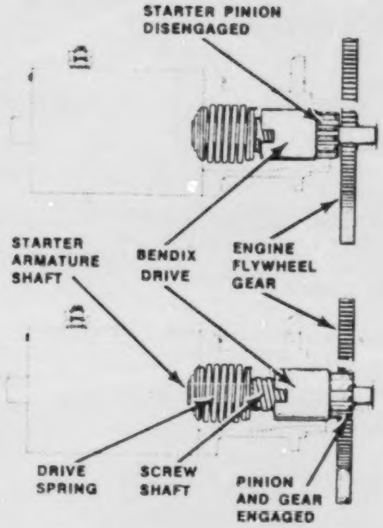
Starter Motor Types

Starter motors are all direct current motors that carry high current for short periods of time. They crank the engine through a drive pinion that engages a ring gear on the engine flywheel. Starter motors are classified by the type of drive mechanism they use. The two most common drive types are the inertia, or Bendix,drive and the positive engagement drive. Positive engagement drives are further classified as solenoid-actuated or movable pole shoe types.

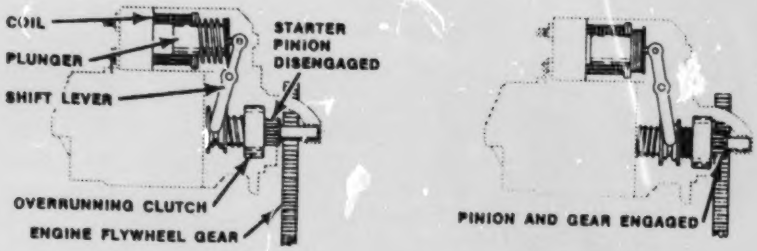
Bendix Drive

The Bendix drive uses inertia to engage the starter drive pinion with the flywheel. The pinion has internal threads which match the threaded armature shaft.

When the starter motor is energized, the armature shaft spins at high speed. Because of the inertia of the pinion, it travels down the threaded shaft until it meshes with the gear teeth on the flywheel. The starter will then crank the engine. When the engine starts, the flywheel causes the pinion to turn faster than the armature shaft. This causes the pinion to disengage from the flywheel.

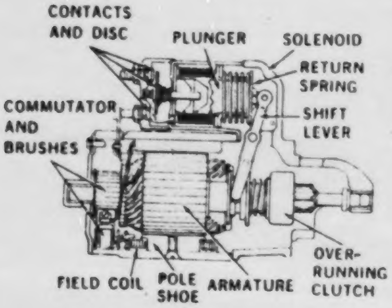

STARTER PINION DISENGAGED
STARTER ARMATURE SHAFT
BENDIX DRIVE
ENGINE FLYWHEEL GEAR
DRIVE SPRING
SCREW SHAFT
PINION AND GEAR ENGAGED

Solenoid-Actuated Drive


COIL
PLUNGER
SHIFT LEVER
STARTER PINION DISENGAGED
OVERRUNNING CLUTCH
ENGINE FLYWHEEL GEAR
PINION AND GEAR ENGAGED

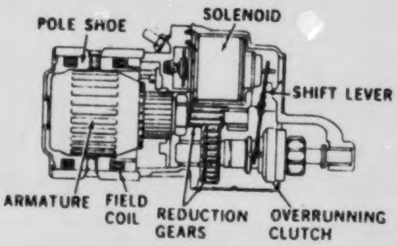
In the solenoid drive, the starter drive pinion is engaged by the starter solenoid. An overrunning clutch disengages the pinion when the engine starts, preventing damage to the flywheel gear teeth or the starter motor.

Solenoid-actuated starters may be either direct drive or reduction gear drive types. In the direct dirve type, the starter drive pinion is operated directly by the motor armature shaft. In the reduction gear type, the drive pinion is driven through two reduction gears.


CONTACTS AND DISC
PLUNGER
SOLENOID
RETURN SPRING
COMMUTATOR AND BRUSHES
SHIFT LEVER
FIELD COIL
POLE SHOE
ARMATURE
OVER-RUNNING CLUTCH

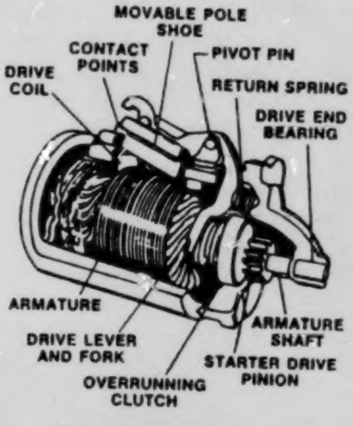
Direct Drive

Most Chrysler-built engines use reduction gear type starters. This types of starter provides additional cranking torque with an approximate 3.5:1 gear ratio.


POLE SHOE
SOLENOID
SHIFT LEVER
ARMATURE
FIELD COIL
REDUCTION GEARS
OVERRUNNING CLUTCH

Reduction Gear Drive

Movable Pole Shoe Drive

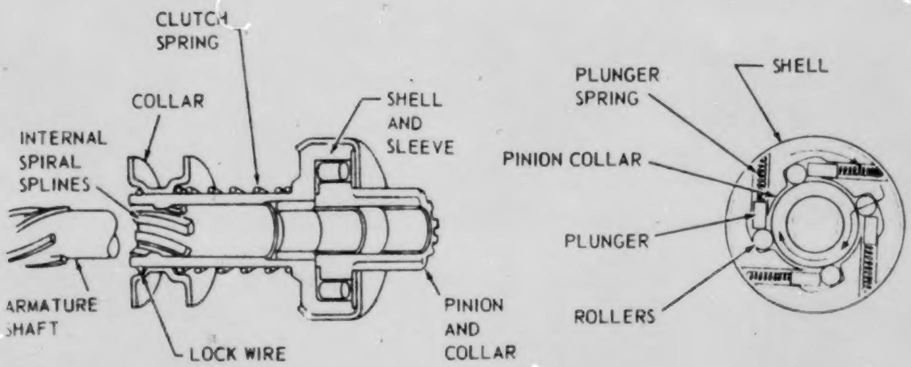

MOVABLE POLE SHOE
CONTACT POINTS
PIVOT PIN
DRIVE COIL
RETURN SPRING
DRIVE END BEARING
ARMATURE
ARMATURE SHAFT
DRIVE LEVER AND FORK
STARTER DRIVE PINION
OVERRUNNING CLUTCH

Movable Pole Shoe Starter

The movable pole shoe drive starter is used on AMC products and on 4-cylinder, 6-cylinder,and small V-8 engines from the Ford Motor Company. In this type of starter,the drive mechanism is an integral part of the motor, and the drive pinion is engaged with the flywheel before the motor is energized.

When the ignition switch is moved to the Start position, current flows through the starting motor drive coil (field coil) and through the contacts to ground. The resulting magnetic field pulls down the movabel pole shoe, opens the contacts, and forces the drive pinion by lever action to engage the flywheel ring gear. A small holding coil keeps the shoe and lever assembly engaged during cranking, and an overrunning clutch disengages the drive pinion when the engine starts. When the ignition switch returns from the Start position, the pole shoe and lever return to their orginal positions.

Overrunning Clutch


CLUTCH SPRING
COLLAR
SHELL AND SLEEVE
INTERNAL SPIRAL SPLINES
ARMATURE SHAFT
LOCK WIRE
PINION AND COLLAR
SHELL
PLUNGER SPRING
PINION COLLAR
PLUNGER
ROLLERS

Cutaway and end sectional views of an overrunning clutch. (Delco-Remy Division of General Motors Corporation)

The overrunning clutch is operated by a shift lever. The lever pushes the drive pinion into mesh with the flywheel teeth. As the shift lever completes its travel, it closes the starting-motor switch so that cranking takes place. Straight or spiral splines in the armature shaft and the clutch sleeve cause both to rotate together. A spiral spring is placed between the clutch housing and the shift-lever collar. This spring compresses if the pinion and the flywheel teeth should happen to butt instead of mesh. Then, after the starting-motor switch is closed and the armature starts to rotate,meshing is completed by the spring pressure.

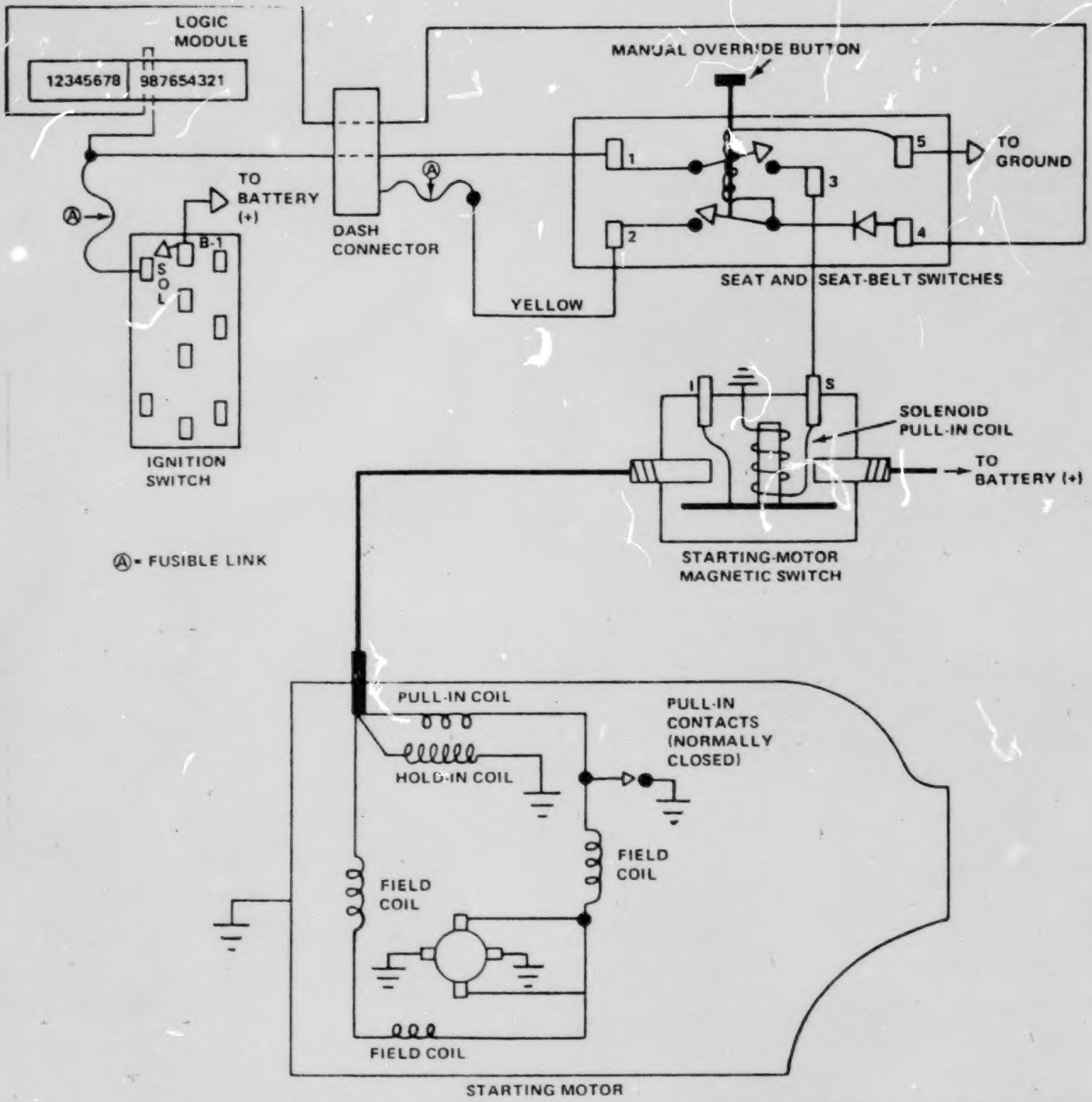
The clutch consists of the outer shell and the pinion and collar assembly. The outer shell has four hardened-steel rollers fitted into four notches. The notches are not concentric,but are smaller in the end opposite to the plunger springs. When the armature and the shell begin to rotate, the pinion does not. This causes the rollers to rotate into the smaller sections of the notches, where they jam tight. The pinion must now rotate with the armature, cranking the engine. After the engine starts,it spins the pinion faster than the armature is turning. The rollers are rotated into the larger sections of the notches, where they are free. This allows the pinion to spin independently of, or overrun, the remainder of the clutch. A spring on the shift lever pulls the pinion back out of mesh when the shift lever is released.

Seat-Belt Starter Interlock System

The seat-belt starter interlock system, introduced on 1974 cars, compels front-seat passengers to buckle their seat belts before the engine can be started. Figure shows the wiring diagram.

The switches shown in the box labeled SEAT AND SEAT-BELT SWITCHES must be closed before the circuit to the starting-motor magnetic switch is completed. Both seat-belt retractors have switches that are open when the belts are not in use. There is a switch under the right front seat that will open if someone sits in the seat. However,if the passenger then puts on the right-hand seat belt, the circuit will close.

NOTE: It is now legal for the automotive mechanic to disconnect the seat-belt starter interlock system. The approved procedure allows the interlock to be bypassed and the buzzer to be disconnected. But the seat-belt warning light must remain operative. Procedures for making the disconnect are available from the vehicle manufacturers.


LOGIC MODULE
12345678
987654321
MANUAL OVERRIDE BUTTON
1
2
3
4
5
TO GROUND
Ⓐ
Ⓐ
TO BATTERY (+)
B-1
SOL
DASH CONNECTOR
YELLOW
SEAT AND SEAT-BELT SWITCHES
IGNITION SWITCH
I
S
SOLENOID PULL-IN COIL
TO BATTERY (+)
STARTING-MOTOR MAGNETIC SWITCH
Ⓐ = FUSIBLE LINK
PULL-IN COIL
HOLD-IN COIL
PULL-IN CONTACTS (NORMALLY CLOSED)
FIELD COIL
FIELD COIL
FIELD COIL
STARTING MOTOR

Starting system for a sliding pole-shoe starting motor, magnetic switch, and seat-belt starter interlock system. *(American Motors Corporation)*

Electrical Compentencies - Cranking System

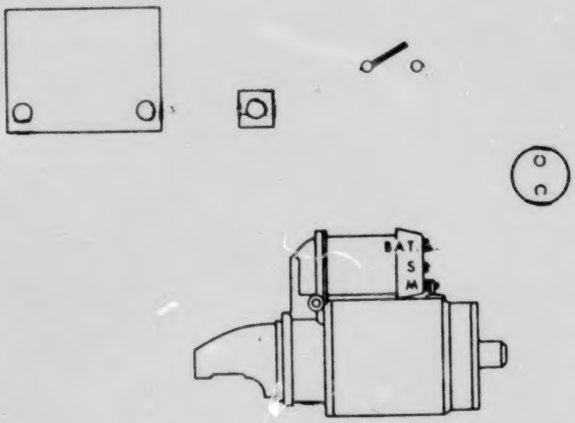
No. D-2 Components and Circuit Idenification

Worksheet # 1

Name ______________________________ Date ______________ Grade ________

DIRECTIONS: Match the number to the correct part

1. Battery
2. Ignition switch
3. Neutral safety switch
4. Solenoid
5. Cranking motor
6. Juction box



Instructor's Initials ______

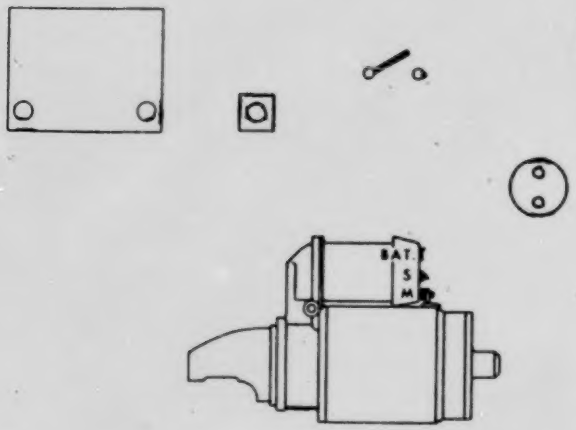
Electrical Compentencies - Cranking System

No. D-2 Components and Circuit Idenification

Worksheet # 2

Name ______________________________ Date ____________ Grade ________

DIRECTIONS: Draw in the wires including all the ground.



Instructor's Initials ________

Electrical Compentencies - Cranking System

No. D-2 Components and Circuit Idenification

Worksheet # 3

Name______________________________________Date_____________Grade___________

T. F. 1. The ignition switch normally has at least four positions.

T. F. 2. The most common type of safety switch used with automatic transmissions is mounted on the steering column.

T. F. 3. The safety switch on a car with an automatic transmission can not be adjusted.

T. F. 4. Most GM starters use the gear reduction type starter motor.

T. F. 5. The Bendix Drive uses inertia to engage the starter drive with the flywheel.

EXPLAIN

6. What is the function of the neutral safety switch?

7. What is the function of the overrunning clutch?

8. Where is the solenoid located on a Chrysler product?

9. What is the advantage of Chrysler's gear reduction starter motor?

DIRECTIONS: Match the component function to the individual components. Place the leter of the function discription to the left of the numbered component.

________ 10. Battery

________ 11. Netural safety switch

________ 12. Starting motor drive

________ 13. Solenoid switch

________ 14. Cranking motor

_______ 15. Relay Switch

_______ 16. Ignition switch

A. The electric motor in the electric system that cranks the engine or turns the crank shaft, for starting

B. Mechanism and gear on the end of the starting-motor armature shaft used to couple the starting motor to and disengage it from the flywheel gear teeth.

C. Magnetic switch which connects the starter to the battery through the heavey battery cable for the brief period that the engine is being cranked.

D. A means of preventing the engine from being started in gear.

E. Supplies electrical energy to power the starting motor.

F. A switch which is opened and closed electromegnetically, by movement of a core.

G. Switch in the ignition system which is operated to open and close the circuit to a solenoid relay.

Instructor's Initials___________

AUTO MECHANICS

Electrical Competencies - Cranking System

No. D-3 Amperage Draw Test

OBJECTIVE: After completion of this exercise you will be able to correctly perform an amperage draw test on the cranking system.

EXPLANATION: The cranking system should not draw more than the specified amperage. If it does it indicates a malfunction in the system. You will look up the specifications, run the test and determine the condition of the system.

MATERIALS NEEDED: Automobile -- Electrical Specifications

TOOLS NEEDED:
Safety Glasses
Battery Starter Tester
Induction Ammeter
Ammeter with heavy shunt

References	Do
#1. Ch.22 p. 43	1. Read reference assignment
#2.	2. Study information sheets
#3.p.638-639, 658-660	3. Do work sheet #1
#4.p.391-392	4. Check with instructor (oral quiz on work sheet #1 and assignment)
#5.p.169-172	5. Test and record the specific gravity of the battery. NOTE: This test will not be valid if the battery is below three-quarters charged.
#6.p.273-275	6. Perform HIGH RATE - DISCHARGE battery test.
#7.p.231-240	7. Remove the coil wire from the center tower of the distributor and, with a jumper wire, ground it. NOTE: Be sure the transmission is in neutral or park and the parking brake is on. Do this whenever the engine is to be
#8.	

References	Do
	cranked for tests.
	INDUCTION AMMETER
	8. Refer to fig. 1
	9. Place induction ammeter over one of the cranking motor cables while the starter is cranking the engine.
	10. Record amperage draw of starter while cranking on work sheet # 2
	HEAVY SHUNT AMMETER
	11. Remove NEGATIVE battery cable.
	12. Place heavy shunt ammeter between negative cable and negative battery post.
	13. Crank engine and read ammeter.
	14. Record amperage draw of starter while cranking on work sheet # 2
	BATTERY - STARTER TESTER
	15. Refer fig. 2
	16. Connect BST to Battery as in fig. 2.
	17. Crank engine with the starter while carefully observing the voltmeter.
	18. Record voltage on work sheet #2
	19. Turn ignition switch off.
	20. Slowly turn carbon pile (load control) knob on the BST while observing the voltmeter
	21 When the voltmeter indicates the same voltage recorded during cranking, observe the ammeter reading. Release the load control.

No. D-3 Amperage Draw Test

References	Do
	22. Record ammeter reading on work sheet #2
	23. Check with instructor

Electrical Competencies - Cranking System

No. D-3 Amperage Draw Test Information Sheet # 1

The system voltage chart lists four possible problems that may exist if the system voltage is too low. The general condition of the starting motor is usually indicated by sluggishness while cranking, overheating, and excessive brush arcing on the commutator. These can be audibly and visually checked out. However, the fourth problem, excessive starting-motor amperage draw, can be determined only by the use of instruments.

There are two approaches to this starting-motor amperage-draw problem. One is to test the amperage draw of the starting motor on the bench while it is free running and without load. This is adequate for a bench test, but a more conclusive test may be conducted on the vehicle while the starting motor is cranking the engine. At this time, natural strains are being placed on the motor. and it may be affected by such conditions as bad bearings, dragging armature, and other problems.

There are three accepted methods of conducting a starting-motor amperage-draw test. One is to place an ammeter with a heavy shunt in series with the starting motor while it is cranking. However, this method is time comsuming and complicated.

Another method is to use an induction ammeter (see Fig. 1). This is a small, inexpensive ammeter that is simply placed over one of the starting-motor cables while the starter[1] is cranking the engine. The reading will be a direct induction indication of how much amperage the starter is drawing. Although this method is not as accurate as the ammeter shunt method. it is much faster.

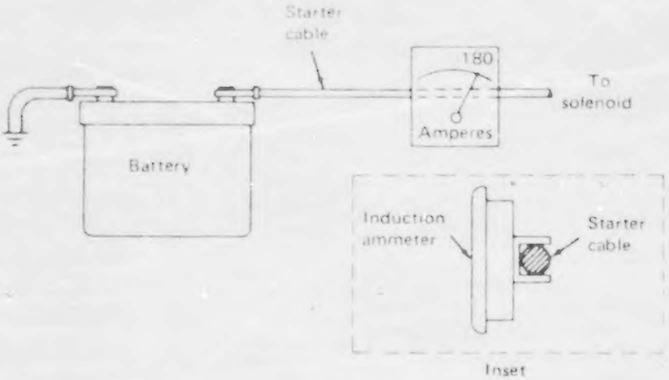


FIG. 1 Induction ammeter placed on starter cable to read starting-motor current draw. Inset shows how meter clip surrounds cable. No leads are required.

NOTE: Some of the newer. more sophisticated instruments also use the induction method to read starter amperage draw from a cable.

The third method is both fast and accurate. Here, the battery-starter tester is used. Using this instrument for the starter draw test makes it easier to combine it with battery tests,since the leads from the battery do not have to be disconnected. The procedure is very simple. With the battery load tester hooked up as in the high-discharge test, simply crank the engine without starting it, and watch the voltage while cranking. Stop cranking the engine, and turn the load knob to the right until the voltage while cranking is duplicated. Check the ammeter at this voltage. This indicates the amperage draw of the starter while cranking the engine. For general diagnosis, the following specifications have been established for this test: small engines, 100 to 150 A; medium engines, 125 to 180 A; and large engines, 180 to 300A. However, the average reading is 200A for 6-V system and 180 A for a 12-V system. You should commit the last two values to memory for the average engine.

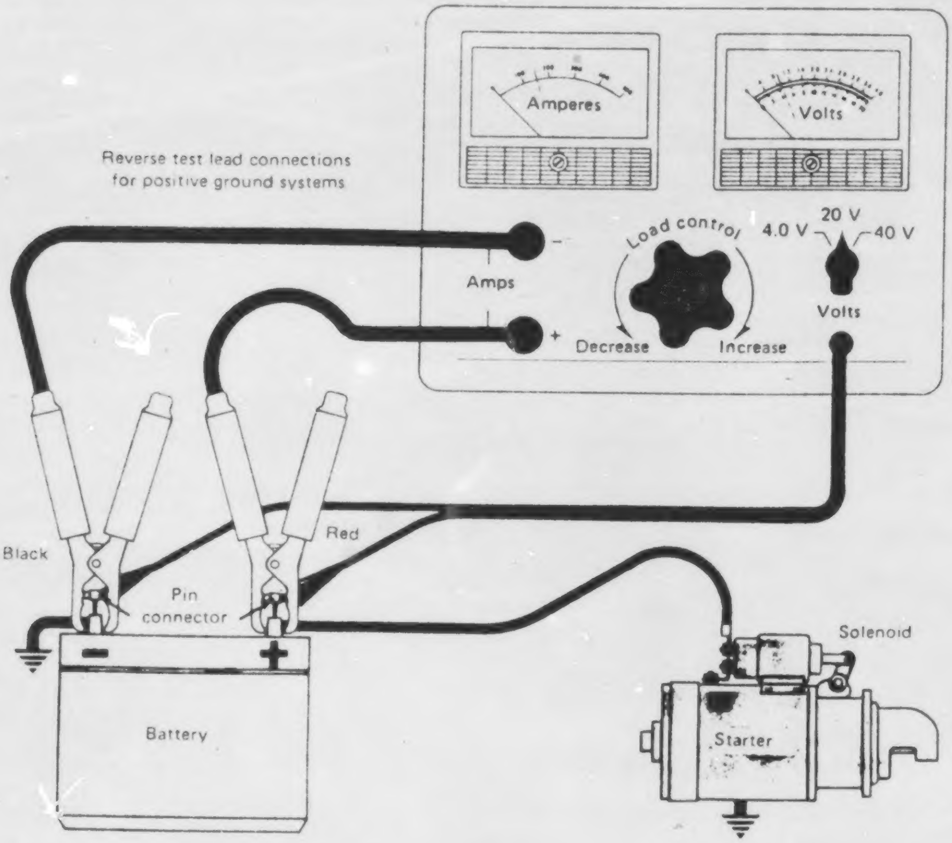

Reverse test lead connections for positive ground systems

FIG. 2 Testing starting-motor amperage draw. (Allen Electric and Equipment Company.)

Electrical Competencies - Cranking System

No.D-3 Amperage Draw Test

Information Sheet # 1

Page 6

NOTE: Current is measured in amperes.

1. Test and record the specific gravity of the battery. Note: This test will not be valid if the battery is below three-quarters charged.

2. Use the battery-load tester. Check the battery for a dead cell(see Sheet 2, Battery Tests). Have the load knob turned to the extreme left (see Fig. 2).

3. Remove the coil wire from the center tower of the distributor and, with a jumper, ground it.

NOTE: Be sure the transmission is in neutral or park and the parking brake is on. Do this whenever the engine is to be cranked for tests.

4. With a starter whip, crank the engine and observe the voltmeter while cranking.

NOTE: The starter whip is a push-button switch connected to two wires. The wires are usually connected to the starter solenoid switch and the live battery cable. This is used to crank the engine instead of the regular starter so that the job can be performed by one person. A starter whip may be homemade or may be purchased [illegible]

5. Stop cranking the engine. Turn the load control knob to the right until the voltage observed in operation 4 is duplicated; at the same time, read the ammeter. The ammeter reading indicates amperage draw of the starter at the time it was cranking. The average reading is 160 A for a 12-V system and 200 A for a 6-V system. Note: See text for other recommended amperage values.

NOTE: Higher-than-average values, accompanied by a sluggish, overheated starter, are an indication that the starter must be removed and serviced or replaced.

6. Replace the coil wire in the center tower of the distributor cap. Be sure it is pushed all the way in for proper seating in the tower connection.

If the starting-motor amperage draw is greater than the value you have chosen for it and the speed is sluggish or the starter is overheated. you can conclude that the starter is drawing too much current while cranking and must be repaired or replaced.

This is not a valid test if the battery is below three-quarters charged or has a dead cell;therefore, eliminate these two conditions before making the starter draw test.

Excessive starter amperage draw causes a drastic reduction in the electric-system voltage while the engine is cranking, even if the battery if fully charged and in good condition. The result is almost sure to be hard starting and abnormally quick discharge of the battery. Under normal conditions, the car must be driven about 8 mi (miles) (13 km (kilometers) to replace the electric energy that was removed from the battery while cranking. Excessive starter amperage draw can be a source of battery trouble (see Fig. 2).

You can expect the starter to draw more current than normal if the engine is "stiff" (hard to crank) for any reason, such as a recent overhaul. Take such conditions into consideration when you make a diagnosis.

If the customer's complaint indicated that the starter was sluggish while cranking, use the starter series of tests for a diagnosis of the trouble.

Electrical Competencies- Cranking System

No. D-3 Amperage Draw Test

Worksheet # 1

Name________________________ Date________________ Grade__________

Starting-Motor Amerage-Draw Tests

1. What happens to the system voltage if the starter is drawing too much current?

2. What is the minimum state of charge that the battery can have before performing on amperage draw test on the cranking motor?

3. Why is the cranking test of the starter superior to the free-running test?

4. State three methods of testing the starter for amperage draw.
   a. ________________ b. ________________
   c. ________________

5. For a 12-V system, what is the average starter amperage draw while the engine is cranking?

6. When the starter draws excessive current, one of the results will be hard starting. State one other.

7. If the customer complains of a sluggish starter while cranking, list the four steps that should be taken.
   a. ________________ b. ________________
   c. ________________ d. ________________

8. What is the objective of Testing the Starting Motor for Amperage Draw?

9. What is a starter whip?

10. How do you know whether to service or replace the starting motor?

Instructor's Initials __________

Electrical Competencies - Cranking System

No. D 3 Amperage Draw Test

Worksheet # 2

Name____Date________________Grade______________

Testing the Starting Motor For Amperage Draw

Year and make ____

Name of owner ____

System voltage: 12 V______ 6 V _______ Other _____________

Specific-gravity record:

__________ __________ ____________ __________ ____________ _____________
Positive 2 3 4 5 6

Is the battery: Fully charged ________ Three-quarters Charged _____ One-half Charged ___
Discharged ________
Battery high-discharge specs. ________ V at __________ A
Battery high-discharge test: ________ V at __________ A Dead cell ____ OK ____

Voltage while cranking specs. _________ V
Voltage while cranking: _________ V(for reference only)

Amperage draw of starter specs. ________
Amperage draw of starter while cranking: _________ A Too high ______ OK _____

Was the starter sluggish while cranking? Yes ________ No______

Did the starter overheat while cranking Yes ________ No _____
(Touch starter to determine this.)

NOTE: If the starter is sluggish,overheating, or drawing too much current, remove it for service or replace it.

Instructor's
Initials _________

AUTO MECHANICS

Electrical Competencies - Cranking Systems

No. D-4 Insulated and Ground Test

OBJECTIVE: After you have completed this exercise you will be able to perform resistance tests on both the insulated and ground circuit of the cranking system.

EXPLANATION: Excessive resistance in the circuit can be the cause of a starting complaint. Excessive resistance is found by using the voltage drop method. These same principle's may be applied to any circuit.

MATERIALS NEEDED: Automobile
Specification book

TOOLS NEEDED: Voltmeter

References	Do
#1.p.22-42	1. Read reference assignment
#2.	2. Study information sheets
#3.p.640-641	3. Do work sheet #1
#4. p.391	4. Check with the instructor (oral quiz or work sheet #1 and assignment)
#5. p.169	5. Test and record the specific gravity of the battery. NOTE: This test will not be valid if the battery is below three-quarters charged.
#6.	6. Perform high-rate discharge battery test.
#7.	7. Remove the coil wire from the center tower of the distributor and, with a jumper wire, ground it. NOTE: Be sure the transmission is in neutral or park and the parking brake is on. Do this whenever the engine is to be cranked for tests.
#8.	

Electrical Competencies - Cranking Systems

No. D 4 Insulated and Ground Test

References	Do
	Insulated Circuit Resistance Test 8. Connect the voltmeter positive lead to the battery positive terminal or post. Do not connect to cable or clamp. NOTE: Fig.1 9. Connect the voltmeter negative lead to the starter motor terminal for the heavy cable. 10. Set the voltmeter on the lowest scale and crank the engine while watching the voltmeter. 11. Record voltage on work sheet #2 Ground Circuit Resistance Test 12. Connect the voltmeter positive lead to the starter housing and the negative lead to the battery negative terminal. Do not connect to the cable or clamp. NOTE: Fig. 2. 13. Set the voltmeter on the lowest scale and crank the engine while watching the voltmeter. 14. Record voltage on work sheet # 2 15. Check with instructor.

No. D-4 Insulated and Ground Tests

Information Sheet # 1

Methods of diagnosing battery troubles and the method of conducting a preliminary starter test have been discussed. The next subject for discussion is excessive resistance in the starter circuit. System voltage is affected by undesirable resistance in the starter circuit in such places as the cables, solenoid, and grounds.

Remember, if the system voltage is too low while the engine is cranking, the result is almost sure to be hard starting, especially in cold weather. Correct system voltage is also important to engine efficiency.

The most accurate method of analyzing the starter circuit for excessive resistance includes the use of the voltmeter. Voltage readings of a certain section of the circuit are taken and transposed into interpretations of resistance for that section. These readings are known as voltage drops. The starter circuit will be used as an example. These same principles may be applied to any circuit.

Four Basic Parts of a Circuit

The starter circuit is divided into four basic parts:

1. The source voltage: The battery or the alternator.
2. The insulated side: Cables and solenoid
3. The main element: The starter
4. The ground side: The frame, engine, and ground straps

A complete analysis of the starter circuit includes a voltage-drop reading of each division. As these tests are conducted, the voltage drops across the battery and the starter should be as high as possible and the voltage drop across the insulated side and the ground side should be as low as possible.

If the starter circuit is to be analyzed, the starter must be cranking the engine without starting. This is usually done by removing the coil wire and employing an assistant; or, if you intend to do the job alone, use a starter whip. It is preferable to make every effort to do a job without an assistant. However, during the first practice sessions of a job project, work with a partner. This will give you exposure to a greater variety of cases. Finally, follow this rule: When a voltage drop is taken, the circuit must be closed and the current flowing in it.

The Insulated Side

The next item to test is the insulated side. Connect the voltmeter from the ungrounded battery post to the starter post. Figure 1 shows a voltmeter connection with emphasis on the prod in the battery post and the connection on the starter post. The immediate reading will be the battery voltage, which will drop as the engine is cranked. Again crank the engine without starting it and watch the voltmeter. While the engine is cranking, select a position on the voltmeter that shows clear graduations in tenths of volt. Then switch back just before you stop cranking. A normal reading is 0.4V. A reading greater than 0.4V indicates that there is excessive resistance between the points tested, that is, between the ungrounded battery post and the starter post. In the typical starter circuit, this could mean loose connections at the battery terminal clamp on the solenoid or at the starter post and burned or oxidized connections at the solenoid contacts.

At this point, the control part of the starter circuit, which is the coil in the solenoid, the start position of the ignition switch, and the intervening wires, neutral switches, and so forth, are not considered. These must be tested under separate procedures, usually outlined in starter service procedures in reference manuals.

If the reading across the insulated side is greater than 0.4V, remove, clean, and retighten all the connections between the points tested with the voltmeter. If this fails, replace the solenoid. Repeat the test when the cleaning and tightening job is done. Occasionally, cheap or worn-out cables may be found. If so, replace the cables. It is possible to check a portion of the insulated side. This can be done on a normal circuit for a given car.

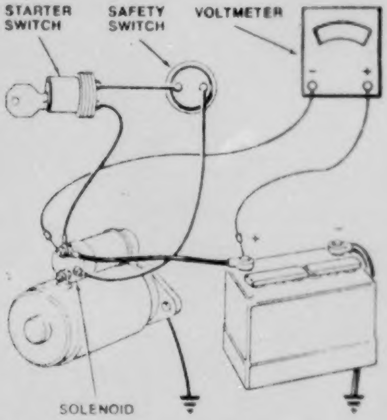
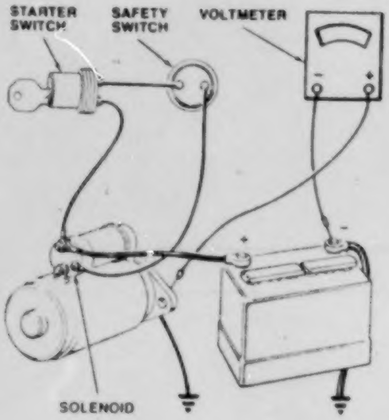


Fig. 1 Insulated Circuit Resistance Test



Ground Circuit Resistance Test Fig.2

The Ground Side

Next, a voltage drop should be conducted across the ground side. Connect the voltmeter across the part of the circuit you wish to check out for resistance. The voltmeter is connected from the starter frame to the grounded battery post. Note that the battery post is again emphasized. Figure 2 Shows that voltmeter connected to the starter frame and the battery post; it also shows the prod used for this purpose. This time you can switch directly to the low-reading position of the voltmeter for better-defined graduations in tenths of a volt. Again, the engine must be cranked and the voltmeter watched. If everything is normal, the voltage-drop reading should not be over 0.2V.

If the voltmeter reading is highter than 0.2V, check the starter to be sure that it is tight on its mounting and that there is no paint or foreign matter between the flange and the starter mounting. Then check out any intervening ground straps such as those sometimes found between the engine and the frame. Check the battery ground cable and make sure it is clean, tight, and in good condition.

Electrical Competencies - Cranking System

No. D-4 Insulated and Ground Tests

Information Sheet # 3

1. Test the specific gravity of the battery. The battery should be three-quarters charged or better for valid series of tests. If too low, recharge the battery before continuing.

2. Conduct a voltage drop across the insulated side as follows. Record on the check-out sheet provided.
   a. Remove the coil high-tension wire from the center distributor-cap tower and ground it so that the engine will not start while it is cranking.
   b. Drive a sharp prod into the positive battery post and connect the positive voltmeter lead to the prod.
   c. Make sure that the voltmeter is set to the right position for 12-V readings. Connect the negative lead to the starter post. Have the voltmeter lead on the starter post itself.
   d. Crank the engine. The voltmeter will drop to a lower reading of about 0.4V under normal conditions. If the voltmeter is equipped with an expanded scale, select this position while the engine is cranking, watch the reading, and return to the original position before you stop cranking. The reading should not be more than 0.4V. The lower the reading the better.

3. Conduct a voltage drop across the ground side as follows and record.
   a. Connect the voltmeter lead to the starter frame.
   b. Connect the negative voltmeter lead to the negative battery post onto a prod driven into the post for that purpose.
   c. Select the expanded-scale position if the voltmeter is equipped with one.
   d. Crank the engine. Watch the voltmeter reading which should not be above 0.2V. The lower the reading, the better.

4. Replace the coil high-tension wire in the center of the distributor cap. Push it all the way in.

Summary

If the insulated-side drop is above 0.4 V, look for loose, dirty, or corroded connections, inadequate cables, or a faulty switch or solenoid somewhere between the points tested.

If the voltage drop across the ground side is more than 0.2 V, look for loose, dirty or corroded ground cable(s), bad or inadequate ground cables, or dirty or loose starter mounting.

Electrical Competencies - Cranking Systems

No. D-4 Insulated and Ground Test

Work Sheet # 1

Name ______________________ Date __________ Grade __________

Starter-Circuit Tests

1. State the four basic parts of the automotive circuit.

   a. ______________________ b. ______________________

   c. ______________________ d. ______________________

2. Give examples of each of the above-named basic parts of the automotive ciruit.

   a. ______________________ b. ______________________

   c. ______________________ d. ______________________

3. What is meant by voltage drop?

   ____

4. Must the current be flowing in a circuit to conduct voltage drops properly?

   ____

5. State at least two things that may be wrong if the drop across the insulated side is greater than 0.4 V.

   a. ______________________ b. ______________________

6. What is the recommended maximum voltage drop across the ground side?

   ____

7. If the voltage drop is above the maximum, state two things that may be the trouble.

   ____

Instructor's Initials __________

Electrical Competencies - Cranking systems

No. D-4 Insulated and Ground Test

Work Sheet # 2

Name ________________________ Date __________ Grade ________

Abbreviated Analysis of the Starter Circuit

Year and make ____________________ ____________________

Name of owner ____

System voltage: 12 V __________ 6 V ______________

Specific-gravity record:

__________	__________	__________	__________	__________	__________
Positive	2	3	4	5	6

Is the battery: Discharged __________ One-half charged ______________

Three-quarters charged ____________ Fully charged ________________

Insulated side: __________ V Too high __________ OK __________
(0.4 V maximum)

Ground side: __________ V Too high __________ OK __________

Is the starter sluggish (cranks slowly)? No__________ Yes____________

NOTE: If conditions are found to be abnormal, and corrections are made to the system, conduct a before-and-after check-out and compare results. Discuss the results with your instructor.

Instructor's Initials ______________

AUTO MECHANICS

Electrical Competencies- Cranking System

No. D-5 Cranking Voltage Test

OBJECTIVE:

After the completion of this exercise you will be able to perform a foltage test on the cranking system.

EXPLANATION:

The cranking voltage test is used with the insulated and ground resistance tests to determine the contition of the cranking system.

MATERIALS NEEDED:

Automobile
Specifications

TOOLS NEEDED:

Voltmeter

References	Do
#1. p.22-42	#1. Read reference assignment.
#2.	#2. Study information sheets.
#3. p. 638-641	#3. Check with instructor (oral quiz and assignment).
#4. p. 391	#4. Test and record on worksheet #1 the specific gravity of the battery. NOTE: This test will not be valid if the battery is below 3/4 charged.
#5.	#5. Set the voltmeter scale on the nearest range above the system voltage.
#6.	#6. For negative-ground systems, attack the voltmeter positive lead to the battery cable terminal on the starter and the negative lead to the starter housing. (see step 7). For positive-ground systems, reverse the connections.
#7.	#7. If the starter motor is inaccessible, connect the voltmeter positive lead to the battery positive terminal and the negative lead to the battery negative terminal.
#8.	#8. Disconnect or ground the ignition.

Electrical Competencies - Cranking System

No. D-5 Cranking Voltage Test

References	Do
	#9. Crank the engine while observing the voltmeter. Do not crank for more than 15 seconds. Record voltage reading on worksheet #2.
	#10. Cranking voltage should not drop below 9.0-9.6 volts for a 12-volt system or 4.8 volts for a 6-volt system. Check the car maker's specifications for exact test values. If the cranking voltage drops below the specified limits, the battery may be undercharged or there may be excessive current draw in the starting system. Test and charge the battery if required and perform the starting system current draw and resistance tests.

Electrical Competencies - Cranking Systems

No. D-5 Cranking Voltage Test

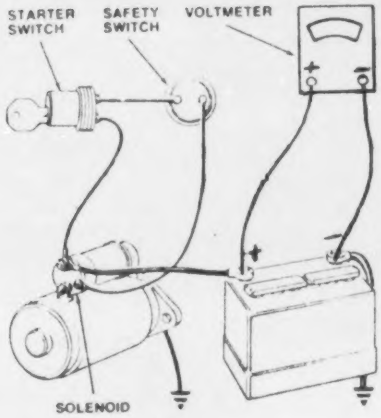
Information Sheet #1

Several general tests can be made with a voltmeter and ammeter or a battery-starter tester to locate starting system problems.

An overall test of cranking voltage can be made with a voltmeter to determine if problems exist with the battery or starting system. If cranking voltage is low,further tests are necessary to pinpoint the problem.

Cranking voltage should not drop below 9.0 to 9.6 volts for a 12-volt system or 4.8 volts for a 6-volt system. Check the car maker's specifications for exact test values.

If the cranking voltage drops below the specified limits, the battery may be undercharged or there may be excessive current draw in the starting system. Test and charge the battery if required and perform the starting system current draw and resistance tests.



Cranking Voltage Test

Electrical Competencies- Cranking System

No. D-5 Cranking Voltage Test

Worksheet #1

Name ______________________ Date ______________ Grade __________

Abbreviated Analysis of the Starter Circuit

Year and make ______________________ ______________________

Name of owner ____

System voltage: 12V __________ 6V ____________

Specific-gravity record:

________	______	______	______	______	______	______
Positive	1	2	3	4	5	6

Is the battery: Discharged ______ One-half charged _____ Three-quarters charged ____
Fully charged _________

Across the battery __________V Too low ________ OK ___________

Is the starter sluggish (cranks slowly)?

NOTE: If conditions are found to be abnormal, and corrections are made to the system, conduct a before-and after check-out and compare results. Discuss the results with your instructor.

Instructor's Initials ______________

AUTO MECHANICS

Electrical Competencies -Cranking System

No. D-6 Cranking Control Circuit Tests

OBJECTIVE: After you have completed this exercise you will be able to perform cranking control circuit test and isolate a defective component.

EXPLANATION: Many cranking complaints can be caused by the cranking motor "controls". (ingnition switch, safety switchs, solenoid and relay switchs) This exercise will help you diagnose the control circuit and it's individual components.

MATERIALS NEEDED: Worksheet # 2
Automobile

TOOLS NEEDED: 12 V Test light

References	Do
#1. Ch. 22 p. 43	1. Read reference assignment
#2. p. 397	2. Study the information sheets
#3. --	3. Do worksheet #1
#4. p. 388	4. Check with instructor (oral quiz on work sheet # 1 and assignment)
	Control Circuit Tests
#5. --	5. Attach test light wire to ground
#6. p. 269,270,271,272	6. Place the test light probe at outlet terminal of solenoid or relay. (Fig. 2) and turn key to start position.
#7. p. 237	
#8. --	

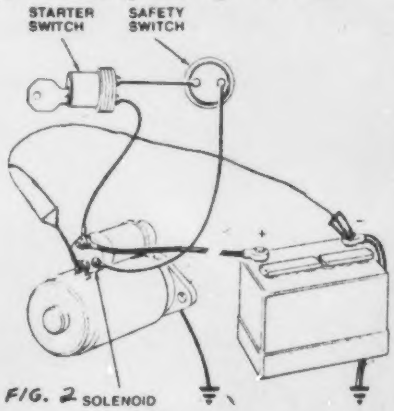


FIG. 2 SOLENOID

References	Do
	7. Record results on worksheet #2

8. If light does not come on place test light probe at S terminal on starter solenoid or relay (Fig. 3) and turn key to start position.

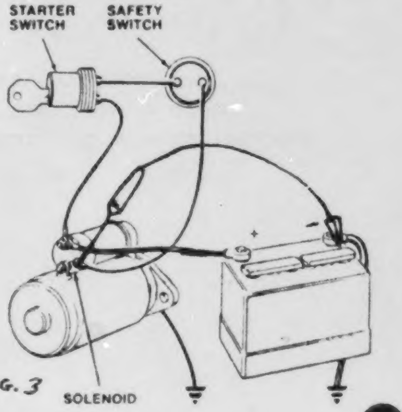

STARTER SWITCH
SAFETY SWITCH
SOLENOID

FIG. 3

9. Record results on worksheet # 2

10. If light does not come on place test light probe at ignition switch side of the Neutral safety switch (Fig. 4) and turn key to start position.

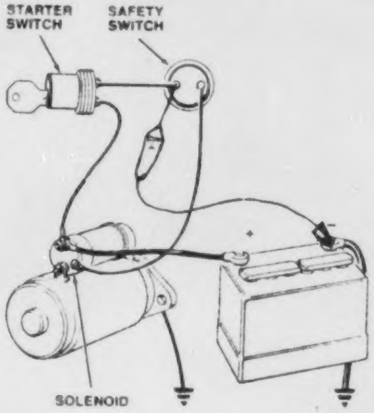

STARTER SWITCH
SAFETY SWITCH
SOLENOID

FIG. 4

11. Record results on worksheet # 2

12. Check with instructor

Electrical Competencies - Cranking Systems

No. D-6 Cranking Motor Control Circuit

Information Sheet # 1

There are various types of controls used with starting motors.

On most installations, a magnetic switch or solenoid is connected in series with the ignition switch. When the switch is turned to the "start" position, the magnetic winding becomes connected to the battery so that the magnetic switches are operated and the circuit between the battery and starter is completed, Fig. 1.

The solenoid switch on a starting motor also shifts the starter pinion into engagement with the flywheel ring gear. This is accomplished by means of linkage between the solenoid plunger, and the shift lever on the starter. When the circuit is completed to the solenoid, current from the battery passes through two separate windings, known as the "pull-in" and "hold-in" windings. The combined magnetic field of these windings pull in the plunger so the drive pinion is shifted into mesh, and the main contacts of the solenoid switch are closed, Fig. 1.

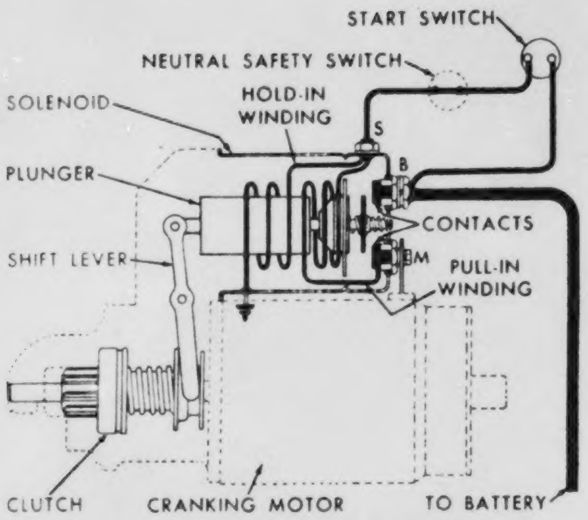


Fig. 1. Schematic of Chevrolet starting motor shows windings of solenoid circuit and details of shift lever and clutch-type starter drive.

Different size wires are used on the two windings, but approximately the same number of turns. The heavy pull-in winding is used to complete the plunger movement, but when the air gap is decreased, the hold-in winding is sufficient to retain the plunger. The closing of the main switch contacts closes the circuit between the battery and the starter and at the same time shorts out the pull-in winding.

When the control circuit is opened, after the engine is started, current no longer reaches the hold-in winding. However, current flows from the battery throught the main switch contacts, through the pull-in winding (in reverse direction) and then throught the hold-in winding to the ground. With the same number of turns of winding in both coils and the same current, the magnetic forces are equal but opposed and counteract each other. Tension of the return spring then causes the plunger to return to the "at rest" position and break the circuit.

Should cranking continue after the control circuit is broken, it would probably be caused by shorted turns in the pull-in circuit or a misalignment of the solenoid resulting in binding of the plunger. Low voltage or an open circuit in the hold-in winding will cause an oscillating action of the plunger. Check for a complete circuit of the hold-in winding as well as the condition of the battery whenever chattering of the switch occurs.

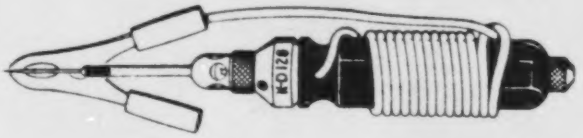
Whenever a solenoid is replaced,it is necessary to adjust the pinion travel. The clearance should be 1/8 to 3/16 in. The exact clearance will vary slightly with different designs.

Neutral Safety Switch

All cars equipped with an automatic transmission are provided with a neutral safety switch, Fig. 1. This switch eliminates the possibility of starting the engine while the transmission selector lever is in position to drive the car, Fig. 1. switch connected is series between the ignition switch and the solenoid.

On some applications, the transmission selector lever may be placed either in PARK or NEUTRAL position before the circuit to the starter is completed. In other installations, it must be placed in PARK position.

HI-LO VOLTAGE
CIRCUIT TESTER



The hi low voltage circuit tester (test light) is used to determine if there is voltage at any given point in an electrical circuit. It must be used in a circuit that is connected to a power source. This tester should not be confused with a continuity tester that contains its own battery.

Electrical Competnecies - Cranking System

No. D-6 Cranking Control Circuit Test

Worksheet # 1

Name ________________________ Date ______________ Grade ________

1. Name the components in the cranking motor control circuit.

   ____

   ____

   ____

2. What are the names given to the two sets of windings in the solenoid?

   ______________________________ ______________________________

3. What two purposes does the solenoid perform?

   ____

   ____

4. If cranking continues after the control circuit is broken the most probable cause would be?

   ____

5. What is the purpose of the neutral safety switch?

   ____

6. In testing the cranking motor control circuit which test instrument is most commonly used?

   ____

NOTE: Be prepared to explain to you instructor the operation of the solenoid.

Instructor's Initials ____________

Electrical Competencies - Cranking System

No.D-6 Cranking Control Circuit Tests

Worksheet # 2

Name ______________________ Date ______________ Grade __________

1. (Fig.2) Test light on ______________ Test light off ______________

Note: If light is on the control circuit is OK.

2. (Fig. 3) Test light on ______________ Test light off ______________

Note: If light is on the solenoid is not working.

3. (Fig. 4) Test light on ______________ Test light off ______________

Note: If light is on the neutral safety switch is not working. If light is not on the problem is in the ignition switch or related wiring. Check with the instructor.

Instructors Initials ______________

AUTO MECHANICS

Electrical Competencies- Cranking System

No. D-7 R & R Solenoid

OBJECTIVE:

At the completion of this exercise you will be able to remove and replace cranking motor solenoids.

EXPLANATION:

The solenoid, when found to be defective, can be replace individually of the cranking motor. There are two solenoid mounting methods that need additional attention, Chrysler Corporations and the Delco style.

MATERIALS NEEDED:

Automobile
Delco starters
Chrysler starters

TOOLS NEEDED:

Hand tools
Sodering iron- Resin and Core Solder

References	Do
#1. --	#1. Read reference assignment
#2. p. 396	#2. Do worksheet #1
#3. p. 646-647, 651-652	#3. For Chrysler Corporation cranking motor solenoids refer to competency D-9 DISASSEMBLE, REPAIR & ASSEMBLE CRANKING MOTOR Information Sheet #
#4. --	#4. Check with instructor
#5. --	
#6. --	
#7. --	
#8. --	

Electrical Competencies- Cranking Systems

No. D-7 R & R Solenoid

Worksheet #1

Name ______________________ Date ____________________ Grade ____________

GM Type Solenoid Removal

1. Remove the outer screw and washer from the motor connector strap terminal.

2. Remove the two screws retaining solenoid housing to end frame assembly.

3. Twist solenoid clockwise to remove flange key from keyway slot in housing; then remove solenoid assembly. (Fig. 1)

Instructor's initials ___________

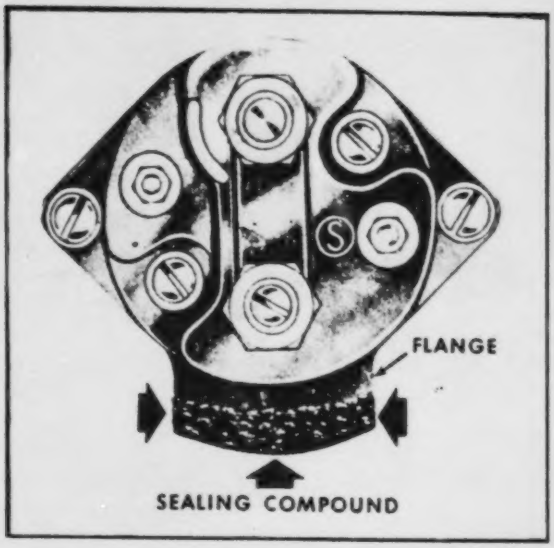


Fig. 1. Sealing solenoid housing to frame

GM Type Solenoid Installation

1. With solenoid return spring installed on plunger, position solenoid body to drive housing and turn counterclockwise to engage the flange key in the keyway slot.

2. Install two screws retaining solenoid housing to end frame.

3. Install outer screw and washer securing motor connector strap terminal. (Fig. 1)

Instructor's initials ___________

AUTO MECHANICS

Electrical Competencies - Cranking System

No. D-8 R & R Starter

OBJECTIVE:

After you have completed this exercise you will be able to Remove and Replace the cranking motor.

EXPLANATION:

Many starting problems are in the cranking motor itself. In order to correct the problem it is NECESSARY to be able to remove the starter before disassembly.

MATERIALS NEEDED:

Automobile
Worksheet #1

TOOLS NEEDED:

Hand tools

References	Do
#1. p. 22-48	#1. Read reference assignment
#2. --	#2. Check with instructor
#3. --	#3. Do worksheet #1
#4. --	#4. Check with the instructor
#5. --	#5. --
#6. p. 278	#6. --
#7. --	#7. --
#8. --	#8. --

Electrical Competencies- Cranking System

No. D-8 R & R Starter

Worksheet #1

Name ______________________ Date ____________ Grade ____________

Starter Removal

1. Disconnect the battery ground cable from the battery terminal part.
2. Remove heat shield if present.
3. Disconnect all wires at the solenoid terminals. Reinstall nuts on terminals to avoid mixing or losing them.
4. Loosen the starting motor front bracket nut or bolt (where present as shown in Fig. 1) and remove the starting motor mounting bolts.

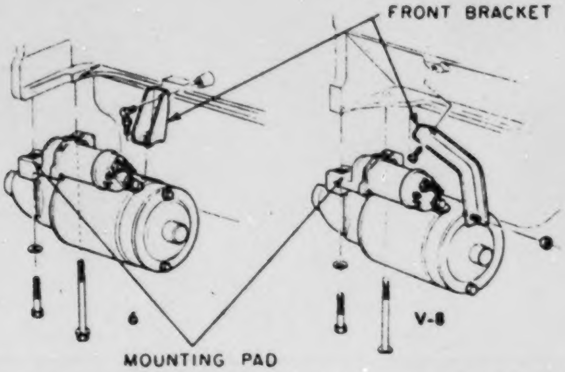


Fig. 1 Starting motors that have a mounting pad and a front-brace bracket. (*Chevrolet Motor Division of General Motors Corporation*)

5. Remove the front bracket nut or bolt and push the bracket out of the way (on installations having a bracket).
6. Pull the starting motor forward and out.
7. Inspect flywheel for damaged or missing teeth.

Instructor's Initials ____________

Starter Installations

1. Install starting motor and replace starting motor mounting bolts.
2. Position front bracket and install front bracket nut of bolt.
3. Connect all wires at the solenoid terminals.
4. Replace heat shield if present.
5. Connect the battery ground cable to the battery terminal post.
6. Try starting motor for correct operation..

Instructor's Initials ____________

AUTO MECHANICS

Electrical Competencies - Cranking Svstem

No. D-9 Disassemble, Test, Repair and Assemble Cranking Motors

OBJECTIVE: At the completion of this exercise you will be able to disassemble, test, repair and assemble various types of automative cranking motors.

EXPLANATION: After a cranking problem has been found to be in the cranking motor it must be disassembled and inspected. If the motor is to be rebuilt the following information will assist you in testing and repairing.

MATERIALS NEEDED: Cranking motors

TOOLS NEEDED: Hand tools
Armature Growler and Test Light
Sodering iron and resin core soder
Bushing removing and installing
Armature reconditioning tools

References	Do
#1. 22-45 through 22-48	1. Read reference assignment
#2. --	2. Read information sheet # 1-4
#3. 644-647, 653-657	3. Do worksheet # 1 (Test on
#4. 389,390,392, 393	information sheet)
#5. --	4. Check with instructor
#6. 275-278	DISASSEMBLE, TEST, REPAIR AND
#7. --	ASSEMBLE CRANKING MOTOR
#8. --	5. Do worksheet # 2
	6. Do worksheet # 3
	7. Do worksheet # 4

Electrical Competencies - Cranking System

No. D-9 Disassemble, Test, Repair and Assemble Cranking Motors

Information Sheet # 1

Different manufacturers have different testing procedures for checking starting motors and circuits on cars. In the next few information sheets the disassembly, repair and assembly procedures for the most common Chevrolet, Chrysler and Ford cranking motors are explained in detail. The electrical tests for the armature and fields are very similar for all cranking motors and will be explained in the following paragraphs.

Testing and Repairs

Armature Test For Shorts

Check the armature for short circuit by placing on growler and holding hack saw blade over armature core while armature is rotated (fig. 1). If saw blade vibrates, armature is shorted. Recheck after cleaning between the commutator bars. If saw blade still vibrates, replace the armature.

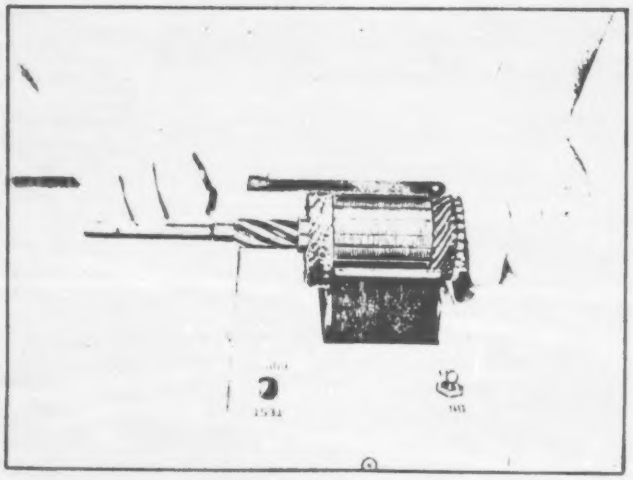


Fig. 1 --Armature Short Circuit Text

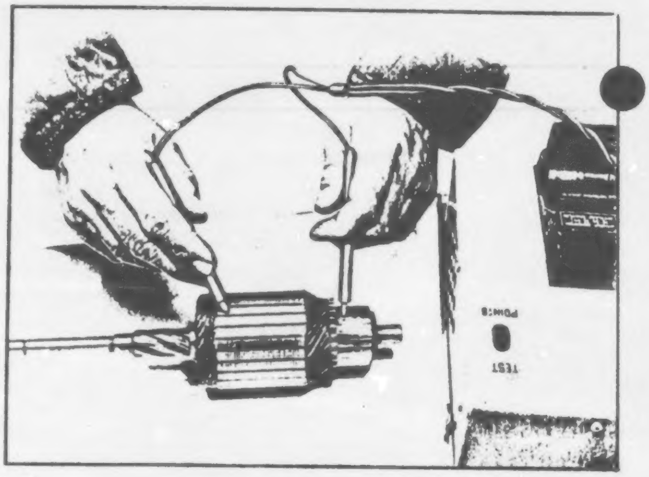


Fig. 2 --Armature Ground Test

Armature Test For Ground

Place one lead on the armature core or shaft and the other on the commutator (fig. 2). If the lamp lights, the armature is grounded and must be replaced.

Field Coil Test For Open Circuit

Place one lead on the insulated brush and the other to the field connector bar (Fig. 3). If the lamp does not light, the field coils are open and will require replacement.

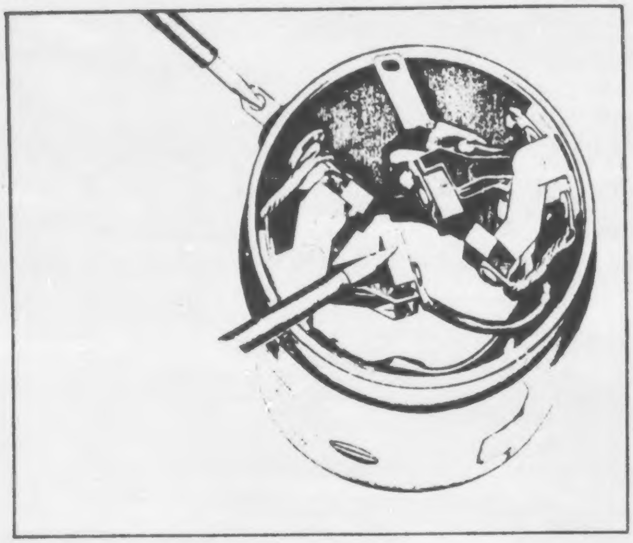


Fig. 3 --Field Coil Open Circuit Test

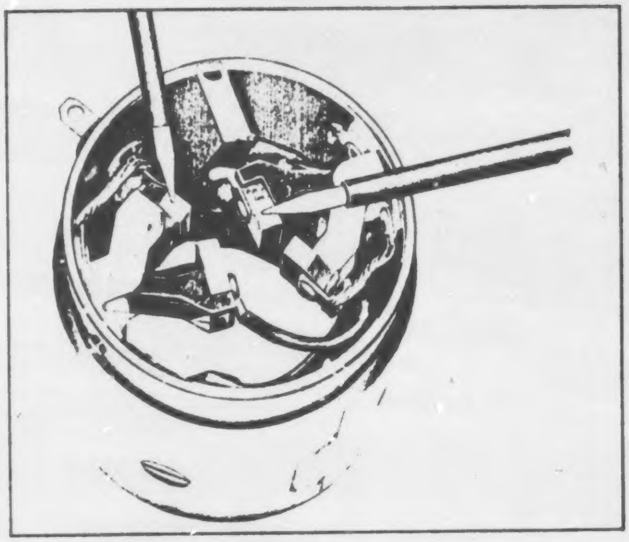


Fig. 4 --Field Coil Ground Test

Field Coil Test For Ground

Place one lead on the connector bar and the other on the grounded brush (fig. 4). If the lamp lights, the field coils are grounded.

NOTE: Be sure to disconnect the shunt coil before performing this test (when applicable).

Loose Electrical Connections

When an open soldered connection of the armature to commutator leads is found during inpection, it may be resoldered provided resin flux is used for soldering.

CAUTION: Acid flux must never be used on electrical connections.

Turning The Commutator

1. Turn down commutator in a lathe until it is thoroughly cleaned (Fig. 5). (See instructor for demonstration on commutator turning equipment).

CAUTION: Do not cut beyond section previously turned.

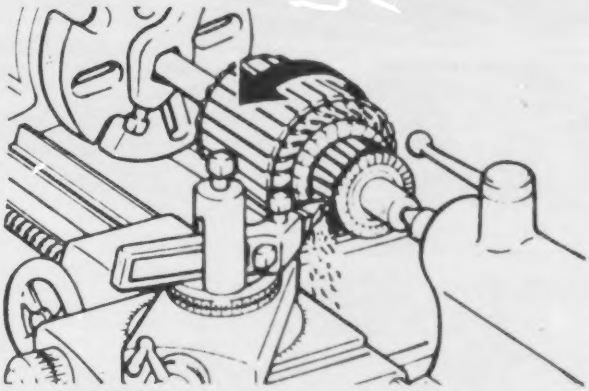


Fig. 5 Turning an armature commutator on a lathe.

2. Undercut insulation between commutator bars 1/32" (Fig. 6). This undercut must be the full width of insulation and flat at the bottom: a triangular groove will not be satisfactory. After undercutting, the slots should be cleaned out carefully to remove any dirt and copper dust (Fig. 7).

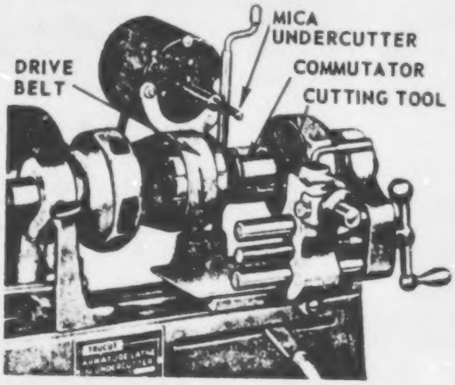

MICA UNDERCUTTER
DRIVE BELT
COMMUTATOR CUTTING TOOL

Fig. 6 Using a special armature lathe to turn commutator. (Trucut)

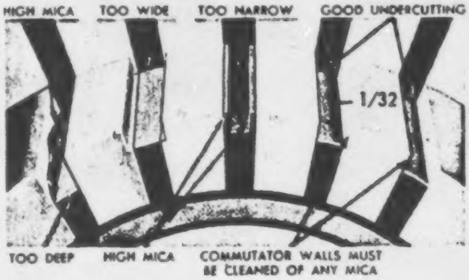

HIGH MICA
TOO WIDE
TOO NARROW
GOOD UNDERCUTTING
1/32
TOO DEEP
HIGH MICA
COMMUTATOR WALLS MUST BE CLEANED OF ANY MICA

Fig. 7 Undercut generator commutator mica insulation to a a depth of 1/32 in. (Ford)

CAUTION: Some starter motor models are a molded armature commutator design and no attempt to undercut the insulation should be made or serious damage may result to the commutator. Undercutting reduces the bonding of the molding material which holds the commutator bars and since the molding material is softer than the copper bars, it is not necessary to undercut the material between the bars of the molded commutator.

3. Sand the commutator lightly with No. 00 sandpaper to remove any slight burrs left from undercutting.

4. Recheck armature on growler for short circuits.

G M Type Starter

Disassembly

Light Duty Models (Figs. 1 and 2)

1. Disconnect the field coil connector(s) from the motor solenoid Terminal.
2. Remove through bolts.
3. Remove commutator end frame, field frame assembly and armature assembly from drive housing.

4. Remove overrunning clutch from armature shaft as follows:
   a. Slide two piece thrust collar off end of armature shaft.
   b. Slide a standard half-inch pipe coupling or other metal cylinder of suitable size (an old pinion of suitable size can be used if available) onto shaft so end of coupling or cylinder butts against edge of retainer (fig. 4). Tap end of coupling with hammer, driving retainer towards armature end of snap ring.
   c. Remove snap ring from groove in shaft using pliers or other suitable tool. If the snap ring is too badly distorted during removal, it may be necessary to use a new one when reassembling clutch. Slide retainer and clutch from armature shaft.

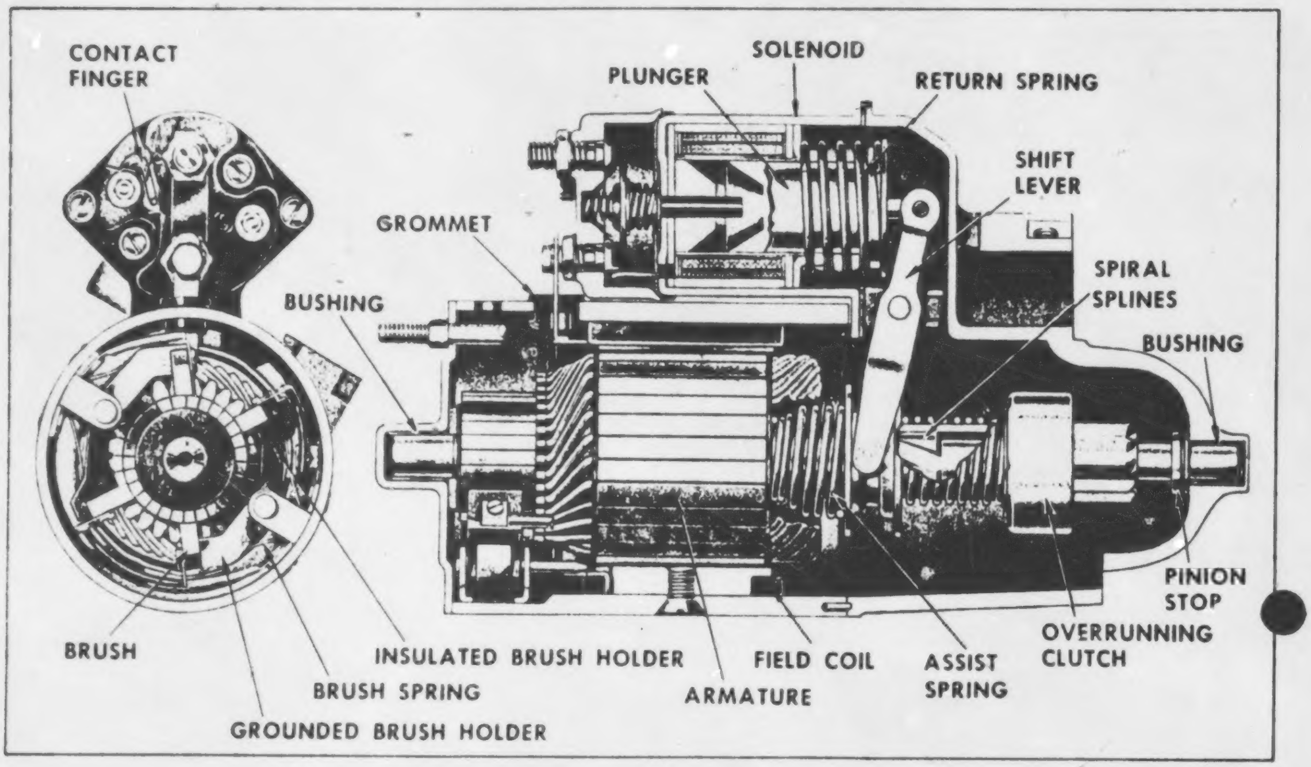
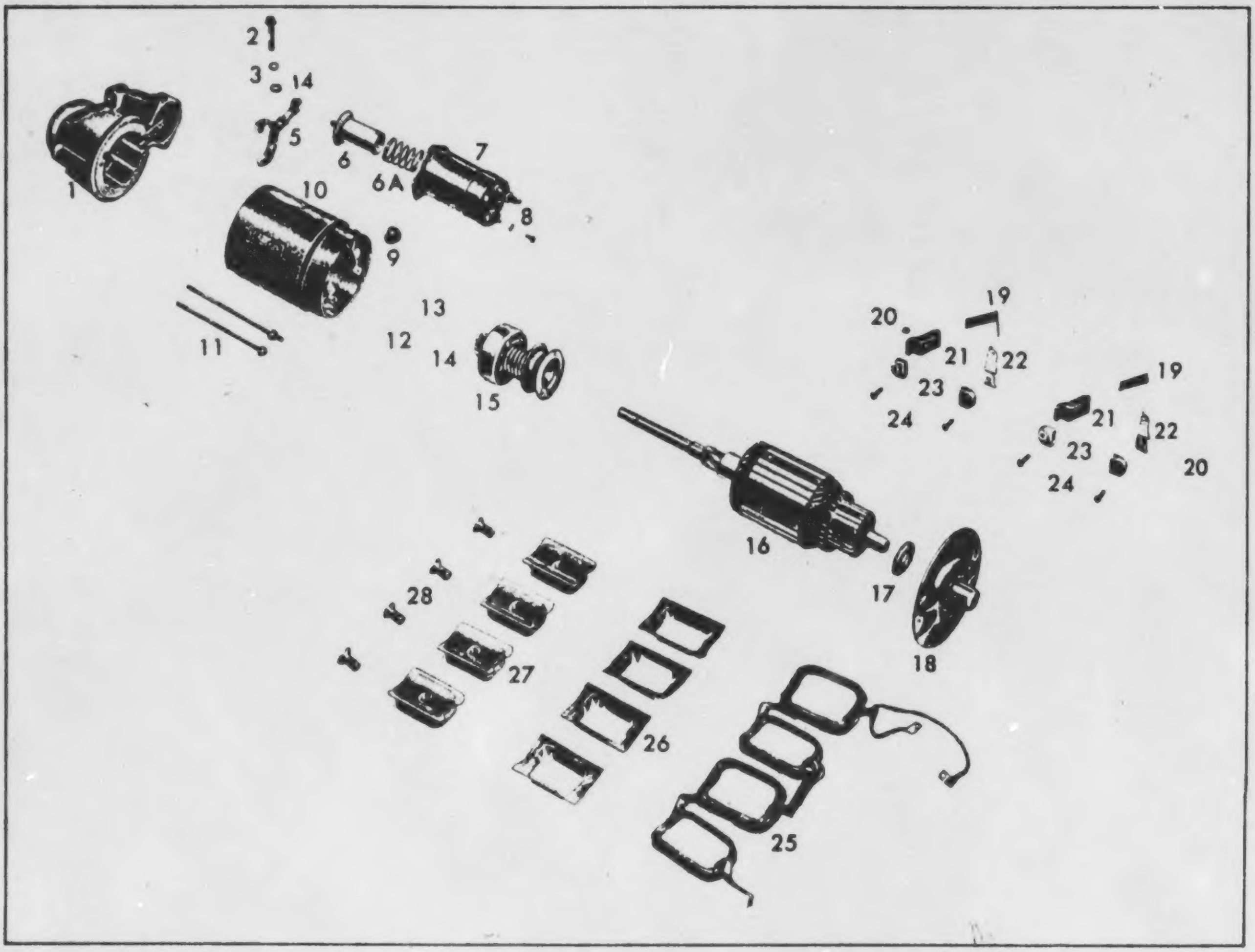

CONTACT FINGER
SOLENOID
PLUNGER
RETURN SPRING
SHIFT LEVER
GROMMET
SPIRAL SPLINES
BUSHING
BUSHING
PINION STOP
OVERRUNNING CLUTCH
BRUSH
INSULATED BRUSH HOLDER
FIELD COIL
ASSIST SPRING
BRUSH SPRING
ARMATURE
GROUNDED BRUSH HOLDER

Fig. 1 --Starting Motor Section (Light Duty)

5. Disassemble brush rigging from field frame.
   a. Release "V" spring from slot in brush holder support (No. 19, Fig.2).
   b. Remove support pin.
   c. Lift brush holders, brushes and spring upward as a unit.
   d. Disconnect leads from each brush.
   e. Repeat operation for other set of brushes.


2
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6A
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Fig. 2 --Starting Motor Parts Layout (Light Duty)

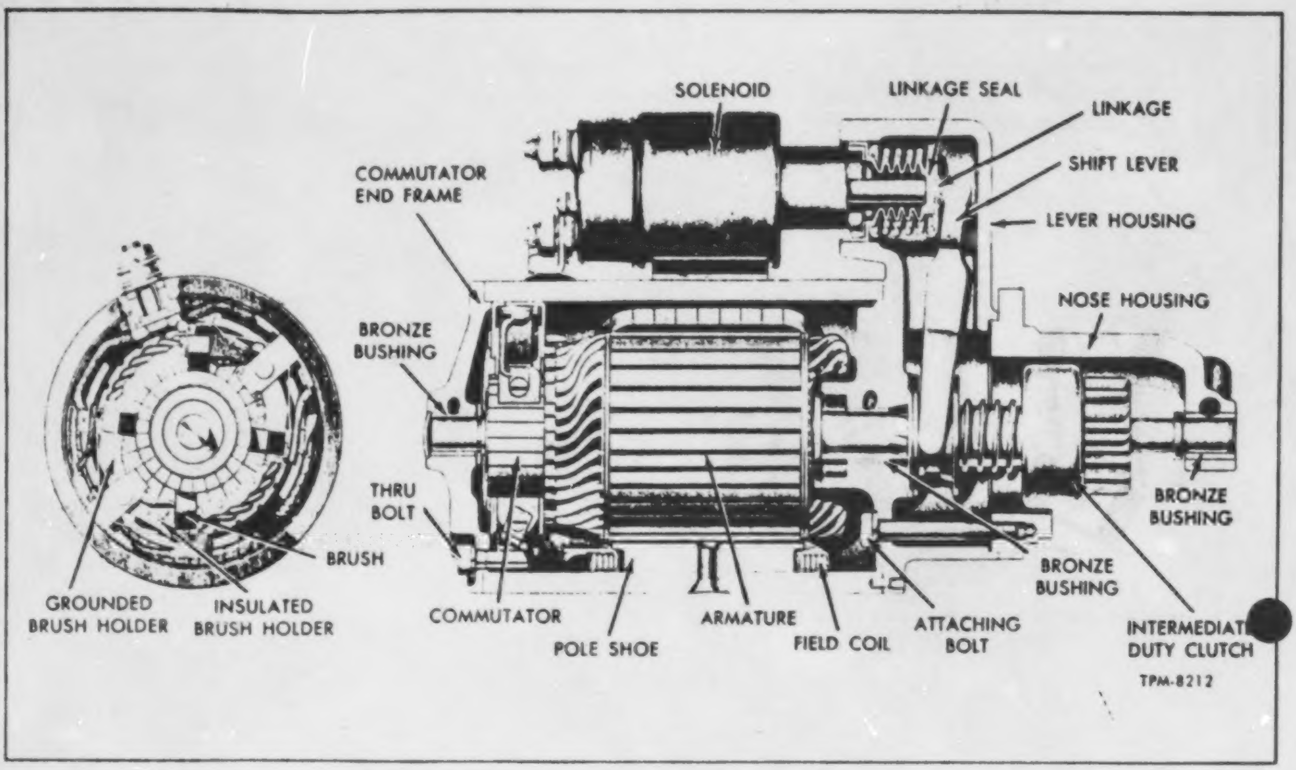

SOLENOID
LINKAGE SEAL
LINKAGE
SHIFT LEVER
LEVER HOUSING
COMMUTATOR END FRAME
NOSE HOUSING
BRONZE BUSHING
BRONZE BUSHING
THRU BOLT
BRUSH
BRONZE BUSHING
GROUNDED BRUSH HOLDER
INSULATED BRUSH HOLDER
COMMUTATOR
POLE SHOE
ARMATURE
FIELD COIL
ATTACHING BOLT
INTERMEDIATE DUTY CLUTCH
TPM-8212

Fig. 3 --Intermediate Duty Overrunning Clutch Type Starting Motor

Intermediate Models (Figs. 2 and 3)

1. Note relative position of solenoid, lever housing, and nose housing so starter can be reassembled in same manner.

2. Disconnect field coil connector from solenoid "motor" terminal, and remove solenoid mounting screws.
3. Remove two through-bolts and lock washers from commutator end frame, then remove commutator end frame from field frame and field frame from lever housing.
4. Remove nose housing attaching bolts and separate nose housing from lever housing.
5. Slide a standard 1/2-inch pipe coupling or other metallic cylinder of correct size onto shaft so end of coupling or cylinder butts against edge of retainer. Tap coupling with hammer to drive retainer toward armature and off snap ring (Fig. 4).
6. Remove snap ring from groove in shaft, using pliers or other suitable tool. If snap ring is distorted during removal it must be discarded and a new one obtained for assembly.
7. Remove armature and clutch from lever housing.
8. Separate solenoid from lever housing.

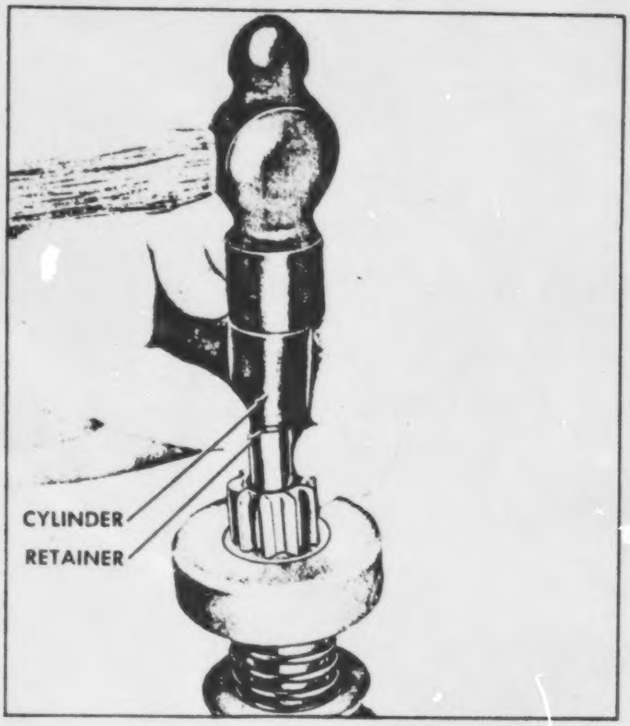


Fig. 4 --Driving Retainer Off Snap Ring

Cleaning and Inspection

With the starting motor completely disassembled except for removal of field coils, the component parts should be cleaned and inspected as described below. Field coils need be removed only where defects in the coils are indicated by the tests described in this section, in which case the pole shoe screws should be removed and the pole shoes and field coils desassembled. Any defective parts should be replaced or repaired (see Repairs).

1. Clean all starting motor parts, but do not use grease dissolving solvent for cleaning the overrunning clutch, armature, and field coils since such a solvent would dissolve the grease packed in the clutch mechanism and would damage armature and field coil insulation.
2. Test overrunning clutch action. The pinion should turn freely in the overrunning direction and must not slip in the cranking direction. Check pinion teeth to see that they have not been chipped, cracked, or excessively worn. Check the spring for normal tension and the drive collar for wear. If necessary the spring or collar can be replaced by forcing the collar toward the clutch and removing lock ring from end of tube.
3. Check brush holders to see that they are not deformed or bent, but will

properly hold brushes against the commutator.

4. Check the condition of the brushes and if pitted or worn to one-half their original length, they should be replaced.
5. Check fit of armature shaft in bushing of drive housing Shaft, should fit snugly in the bushing. If the bushing is worn, it should be replaced. Apply a silicone lubricant to this bushing before reassembly. Avoid axcessive lubrication.
6. Check fit of bushing in commutator end frame. If this bushing is damaged or worn excessively, the end frame assembly must be replaced. Apply a silicone lubricant to this bushing before reassembly. Avoid excessive lubrication. Lubricant forced onto the commutator would gum and cause poor commutation with a resulting decrease in cranking motor performance.
7. Inspect armature commutator. If commutator is rough or out of round, it should be turned down and undercut. Inspect the points where the armature conductors join the commutator bars to make sure that it is a good firm connection. A burned commutator bar is usually evidence of a poor connection. See "Turing the Commutator," dexcribed under Testing and Repairs.

Brush Holder Replacement

If brush holders are damaged, they can be replaced by special service units which are attached with screws and nuts.

Assembly

After all parts have been thoroughly tested and inspected and worn or damaged parts replaced, the starter should be reassembled.

1. Assemble brush rigging to field frame.
   a. Assemble brushes to brush holders.
   b. Assemble insulated and grounded brush holder together with the "V" spring and position as unit on the support pin. Push holders and spring to bottom of support and rotate spring to engage the "V" in slot in support.
   c. Attach ground wire to grounded brush and field lead wire to insulated brush.
   d. Repeat for other set of brushes.

2. Assemble overrunning clutch assembly to armature shaft.
   a. Lubricate drive end of armature shaft with silicone lubricant.
   b. Slide clutch assembly onto armature shaft with pinion outward.
   c. Slide retainer onto shaft with cupped surface facing end of shaft (away from pinion).
   d. Stand armature on end of wood surface with commutator down. Position snap ring on upper end of shaft and hold in place with a block of wood. Hit wood block a blow with hammer forcing snap ring over end of shaft (fig. 5). Slide snap ring down into groove.
   e. Assemble thrust collar on shaft with shoulder next to snap ring.
   f. Place armature flat on work bench, and position retainer and thrust collar next to snap ring. Then using two pair of pliers at the same time (one pair on either side of the shaft), grip retainer and thrust collar and squeeze until snap ring is forced into retainer (fig. 6).

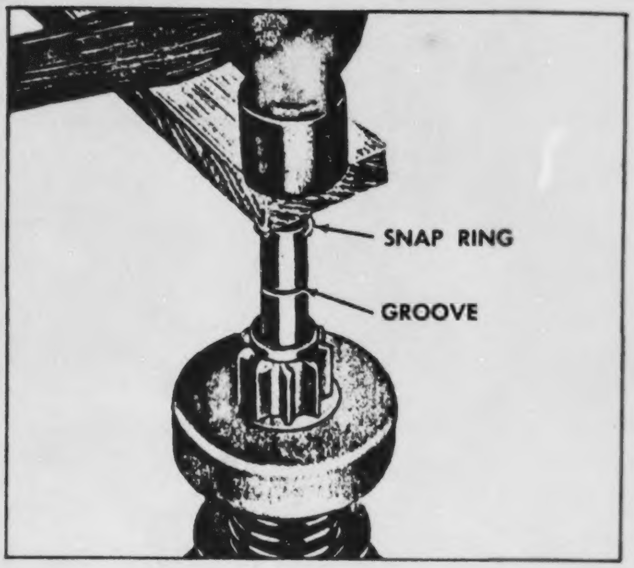


Fig. 5 --Forcing Snap Ring Over Shaft

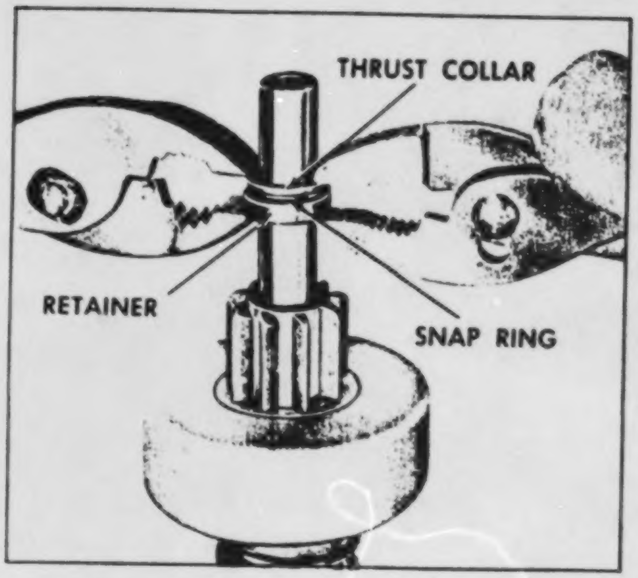


Fig. 6 --Forcing Snap Ring Into Retainer

3. Lubricate the drive housing bushing with a silicone lubricant. Make sure thrust collar is in place against snap ring and retainer and slide armature and clutch assembly into place in drive housing engaging shift lever with clutch.

4. Position field frame over armature and apply special sealing compound betwwen frame and solenoid case. Position frame against drive housing using care to prevent damage to the brushes.

5. Lubricate the bushing in the commutator end frame with a silicone lubricant. Place leather brake washer on armature shaft and slide commutator end frame onto shaft.

6. Reconnect the field coil connectors to the "motor" solenoid terminal.

7. After overhaul is completed, perfrom "Pinion Clearance Check".

Intermedicate Models

1. Install solenoid to lever housing.
2. Insert armature shaft through lever housing and install clutch assembly on shaft.
3. Place retainer over armature shaft with cupped surface facing end of shaft. Install snap ring in groove of shaft.
4. Place a suitable washer on top of snap ring and using two pair of pliers, force retainer over snap ring. REMOVE WASHER AFTER OPERATION.
5. Assemble nose housing to lever housing in same position as before dissembling.
6. Install field frame to lever housing and commutator and frame to field frame, using thru bolts.
7. Install solenoid mounting screws and connect field coil connector to solenoid "motor" terminal.
8. After overhaul is completed, perform "Pinoin Clearance Check".

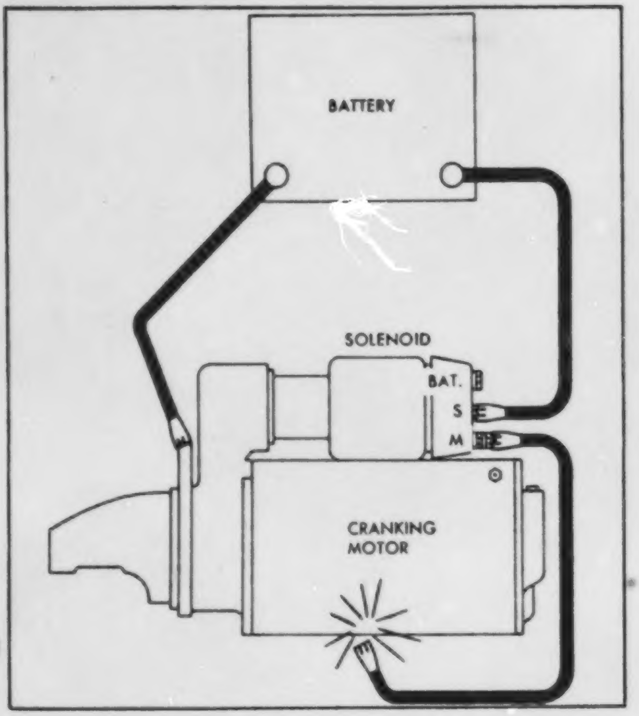


Fig. 7 -Circuit for Checking Pinion Clearance

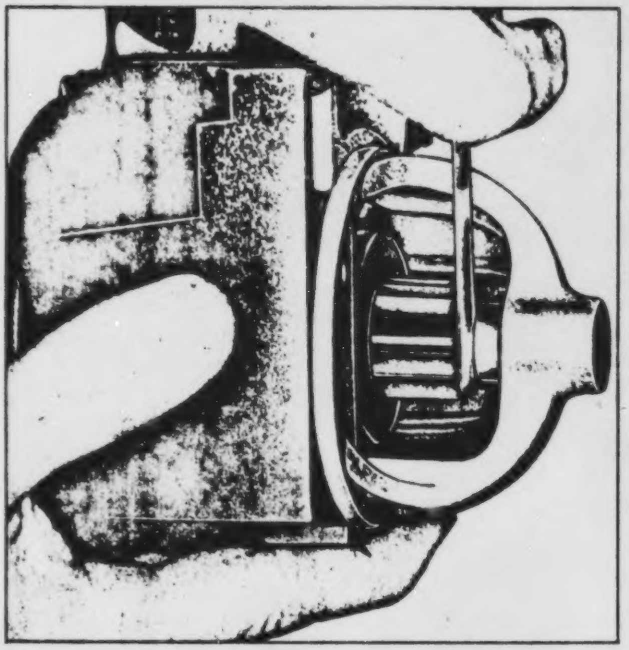


Fig. 8 -Checking Pinion Clearance

Pinion Clearance Check

1. Connect a battery, of the same voltage as the solenoid, from the solenoid switch terminal to the solenoid frame or ground terminal (fig. 7).

NOTE: Disconnect the motor filed coil connector for this test.

2. Monentarily flash a jumper lead from the solenoid motor terminal to the solenoid frame or ground terminal. The pinion will now shift into cranking position and will remain there until the battery is disconnected.

3. Push the pinion back towards the commutator end to eliminate slack movement.

4. Measure the distance between the pinion and pinion stop (fig. 8). If clearance is not within specified limits (.010-.140) it may indicate excessive wear of solenoid linkage shift lever yoke buttons or improper assembly of the shift lever mechanism. Worn or defective parts should be replaced.

Electrical Competencies- Cranking System

No. D-9 Disassembly, Test, Repair and Assemble
Cranking Motor

Information Sheet #3

Chrysler Type Starter

Disassembling the Starter

1. Remove through bolts and end head assembly, (Fig. 1).
2. Carefully remove armature from gear housing and field frame assembly, by pulling outwards, (Fig. 2).
3. Carefully pull field frame assembly from gear housing far enough to expose terminal screw.
4. Remove terminal screw. It may be necessary to support terminal by placing finger behind it, (Fig. 3).

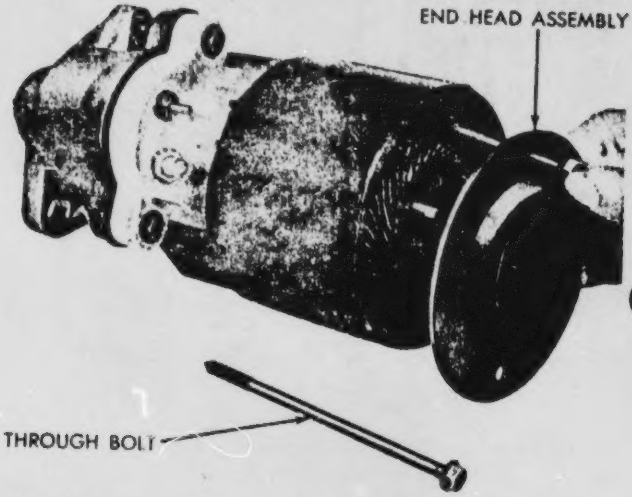

END HEAD ASSEMBLY
THROUGH BOLT

Fig. 1—Removing Through Bolts and End Head Plate

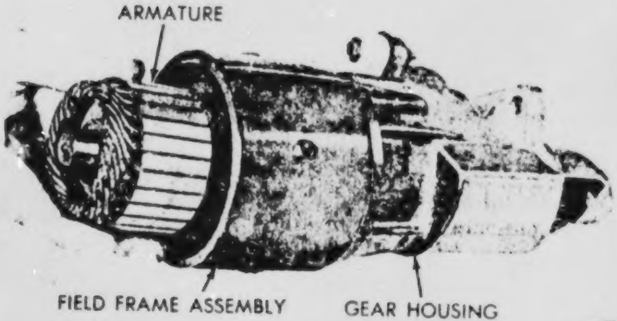

ARMATURE
FIELD FRAME ASSEMBLY
GEAR HOUSING

Fig. 2—Removing Armature

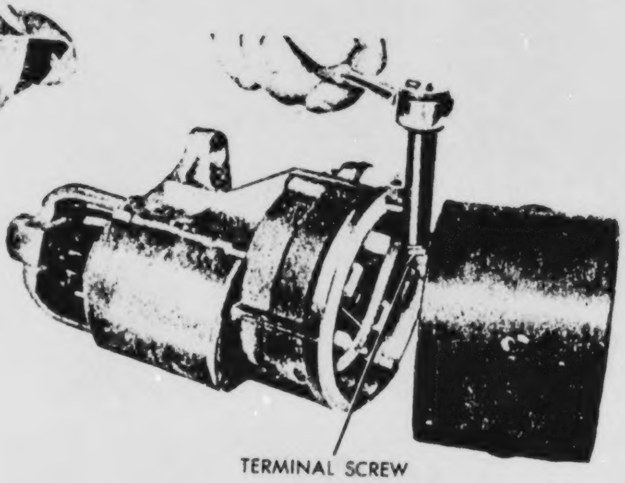

TERMINAL SCREW

Fig. 3—Removing Terminal Screw

5. Remove field frame assembly.
6. Remove nuts attaching solenoid and brush holder plate assembly to gear housing, (Fig.4).
7. Remove solenoid and brush plate assembly from gear housing, (Fig. 5).
8. Remove nut, steelwasher, and sealing washer from solenoid terminal, (Fig. 6).

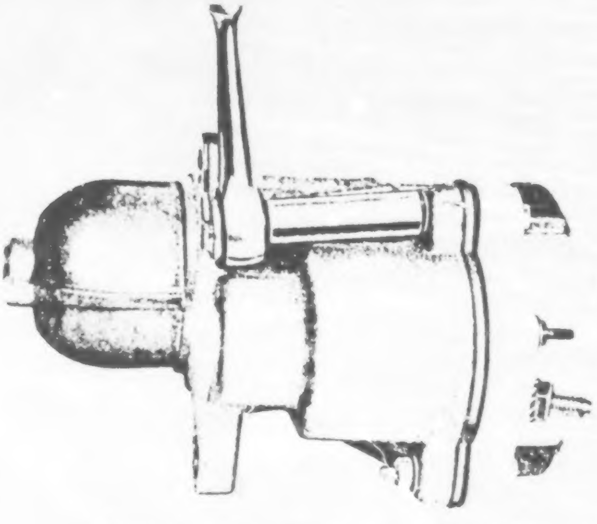


Fig.4—Removing Solenoid and Brush Plate Attaching Nuts

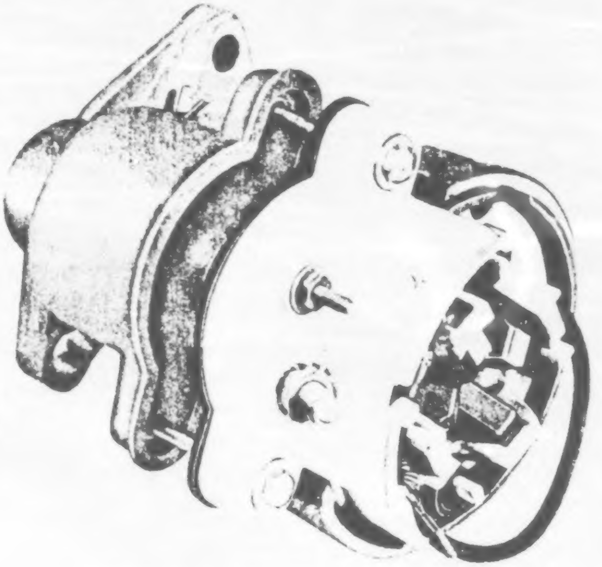


Fig. 5 —Removing Solenoid and Brush Plate Assembly from Gear Housing

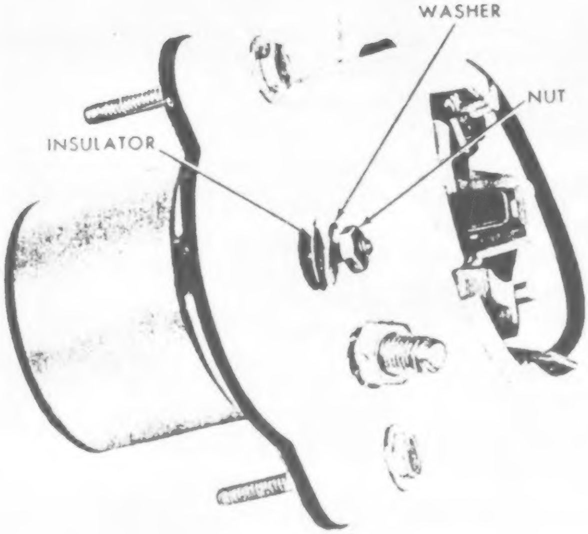


Fig. 6 —Removing Nuts and Washers from Solenoid Terminal

9. Unwind solenoid lead wire from brush plate, (Fig. 7).
10. Remove screws attaching solenoid to brush plate, (Fig: 8)
11. Remove solenoid from brush plate, (Fig.9).

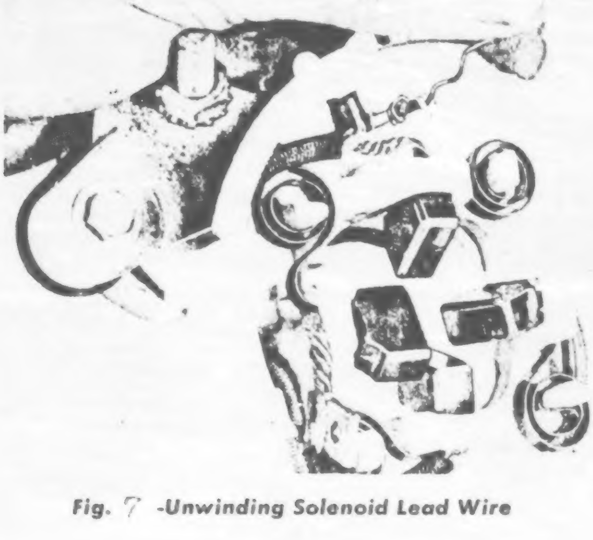


Fig. 7 -Unwinding Solenoid Lead Wire

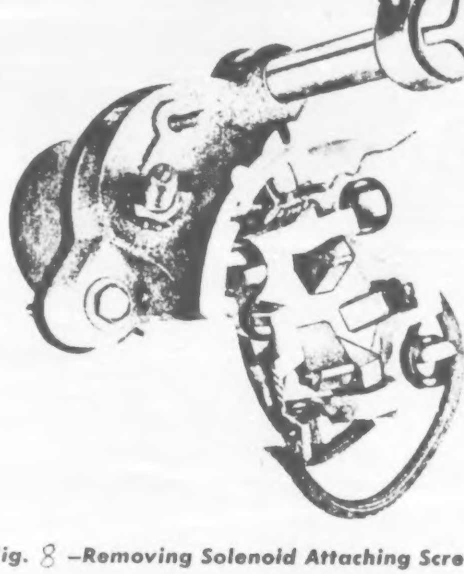


Fig. 8 –Removing Solenoid Attaching Screws

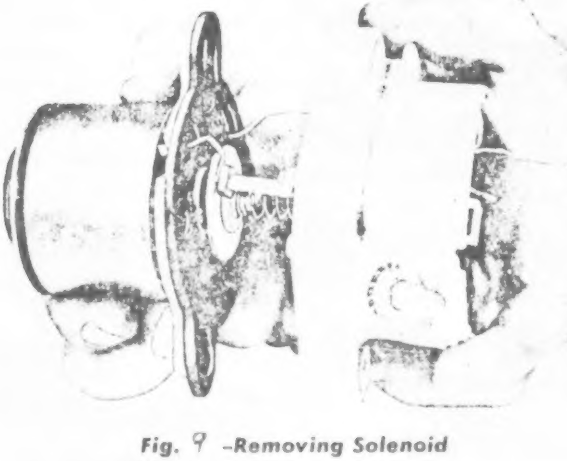


Fig. 9 –Removing Solenoid

12. On brush plate remove nut from battery terminal and remove terminal, (Fig. 10).
13. Remove solenoid contact and plunger assembly from solenoid, (Fig. 11).
14. Remove return spring from inside of solenoid moving core, (Fig. 12).
15. Remove dust cover from gear housing, (Fig. 13).

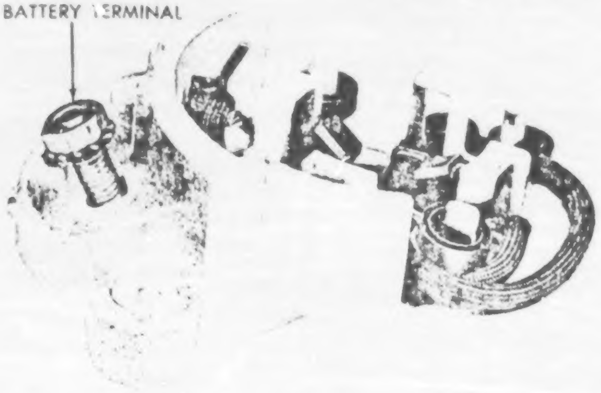


Fig. 10 – Removing Battery Terminal Nut and Washer

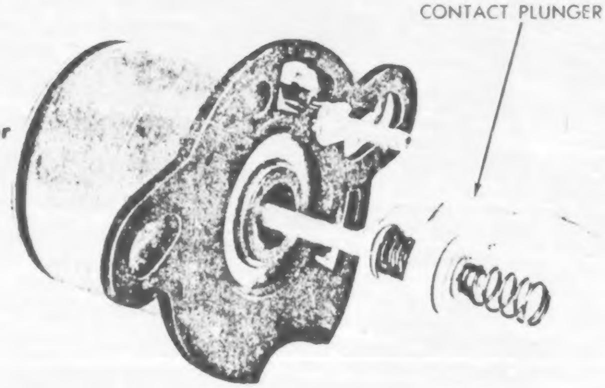


Fig. 11 – Removing Contact and Plunger

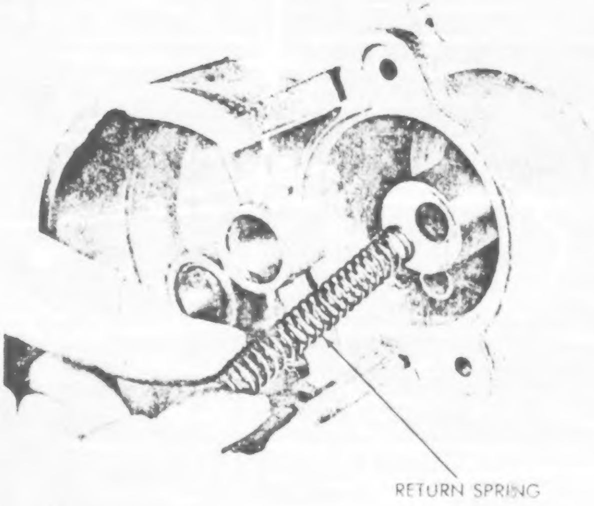


Fig. 12 – Removing Return Spring

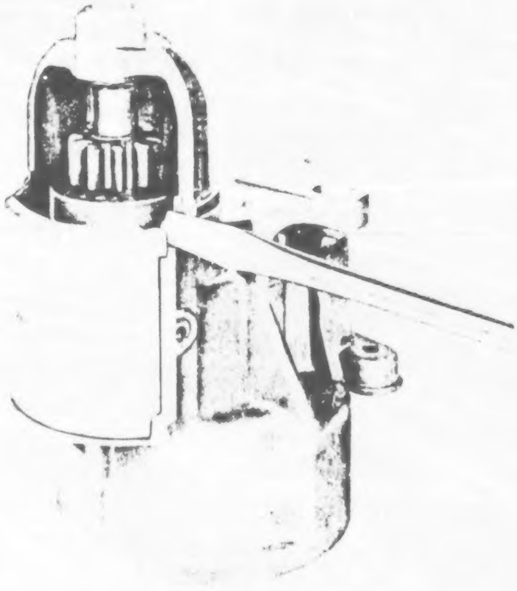


Fig. 13 – Removing Dust Cover

16. Release retainer clip that positions driven gear on pinion shaft, (Fig. 14). CAUTION: Retainer is under tension and a cloth should be placed over the retainer to prevent it from springing away after removal.
17. Remove pinion shaft "C" clip, (Fig. 15).
18. Push pinion shaft towards rear of housing (Fig. 16) and remove retainer ring and thrust washers, clutch and pinion assembly, with the two shift fork nylon actuators as an assembly (Fig. 17).

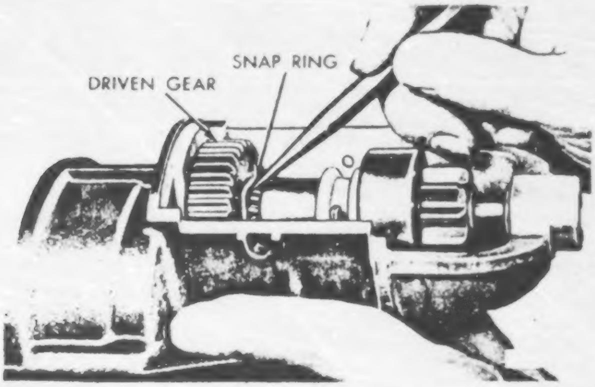

SNAP RING
DRIVEN GEAR

Fig. 14 –Removing Driven Gear Snap Ring

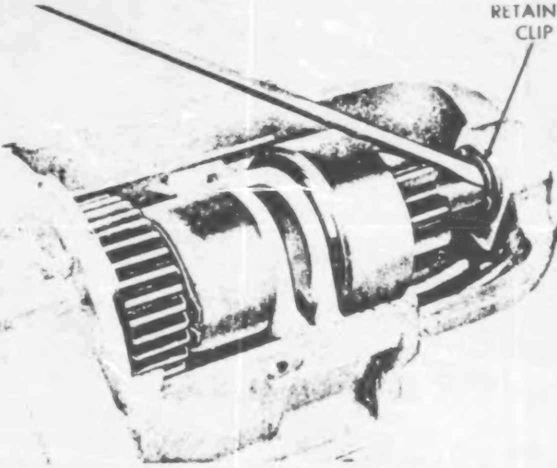

RETAINER CLIP

Fig. 15–Removing Pinion Shaft "C" Clip

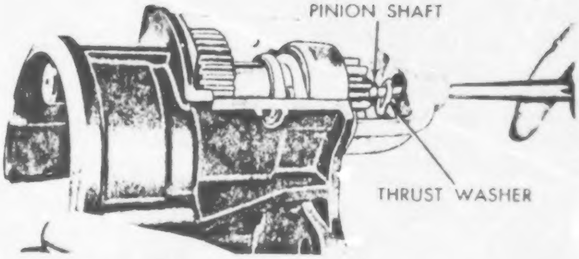

PINION SHAFT
THRUST WASHER

Fig. 16 –Removing Pinion Shaft

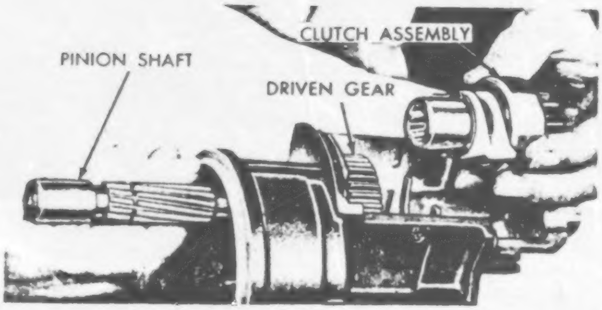

CLUTCH ASSEMBLY
PINION SHAFT
DRIVEN GEAR

Fig. 17 –Removing Clutch Assembly

19. Remove driven gear and friction washer.
20. Pull shifting fork forward and remove solenoid moving core (Fig. 18)
21. Remove shifting fork retainer pin (Fig. 19) and remove clutch shifting fork assembly.

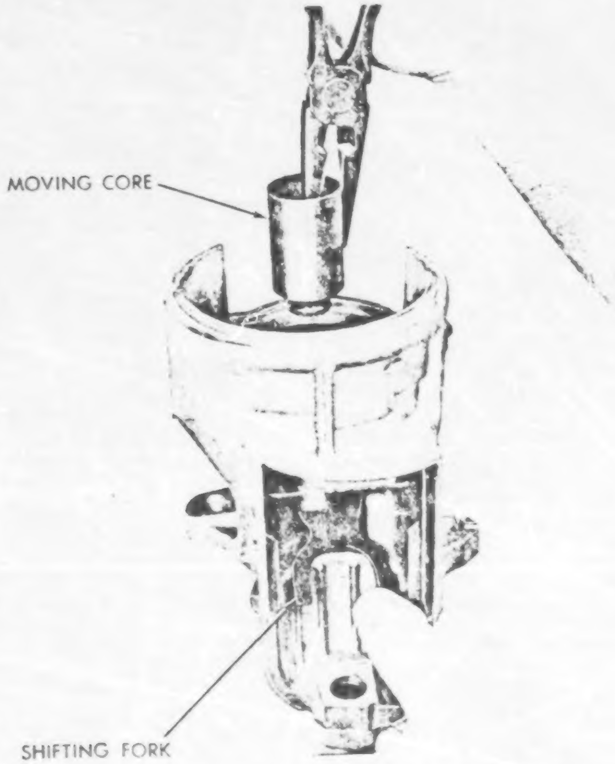

MOVING CORE
SHIFTING FORK

Fig. 18 —Removing Solenoid Core

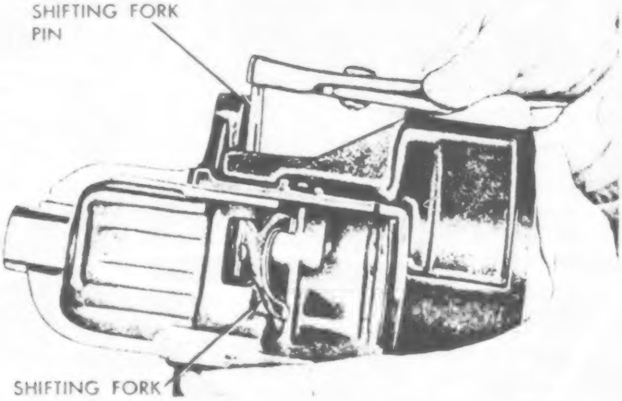

SHIFTING FORK PIN
SHIFTING FORK

Fig. 19 —Removing Shifter Fork Pin

Cleaning the Starter Parts

1. Do not immerse parts in cleaning solvent. Immersing field frame and coil assembly and/or armature will damage insulation. Wipe these parts with a clean cloth only.
2. Do not immerse clutch unit in cleaning solvent. The clutch is pre-lubricated at the factory and solvent will wash lubricant from the clutch.
3. The starter-clutch outer housing and pinion gear may be cleaned with a cloth moistened with cleaning solvent and wiped dry with a clean dry cloth.
4. Clean terminal contacts and contactor with crocus cloth.
5. Thoroughly clean outside area of brush plate to remove all oil and dirt.

Replacement of Brushes and Springs

1. Brushes that are worn more than 1/2 the length of new brushes, or are oil-soaked, should be replaced.
2. When soldering the solenoid lead, make a strong low resistance connection using a high temperature solder and resin flux. Do not use acid or acid core solder.
3. Measure brush spring tension with a spring scale hooked under the spring near the end. Pull scale on a line parallel to the edge of brush and take a reading just as spring leaves brush. Spring tension should be 32 to 36 ounces. Replace springs that do not meet specifications.

Servicing the Starter Bushings

Inspect armature shaft bearing, pinion shaft surfaces and bushings for wear. Try the bushings for wear by inserting the shafts and test for side play.

All of the gear reduction motor bushings can be replaced with the exception of the end head bushing. End head bushing and end head are serviced as an assembly.

Servicing the Starter Clutch Unit

Do not immerse starter clutch unit in a cleaning solvent. Starter clutch is pre-lubricated at the factory and a solvent will wash lubricant from the clutch.

The starter clutch outer housing and pinion gear may be cleaned with a cloth moistened with a cleaning solvent and wiped dry with a clean dry cloth.

Rotate the pinion. Pinion gear should rotate smoothly in one direction (not necessarily easily), but should not rotate in opposite direction. If starter clutch unit does not function properly, or pinion is worn, chipped or burred, replace starter clutch unit.

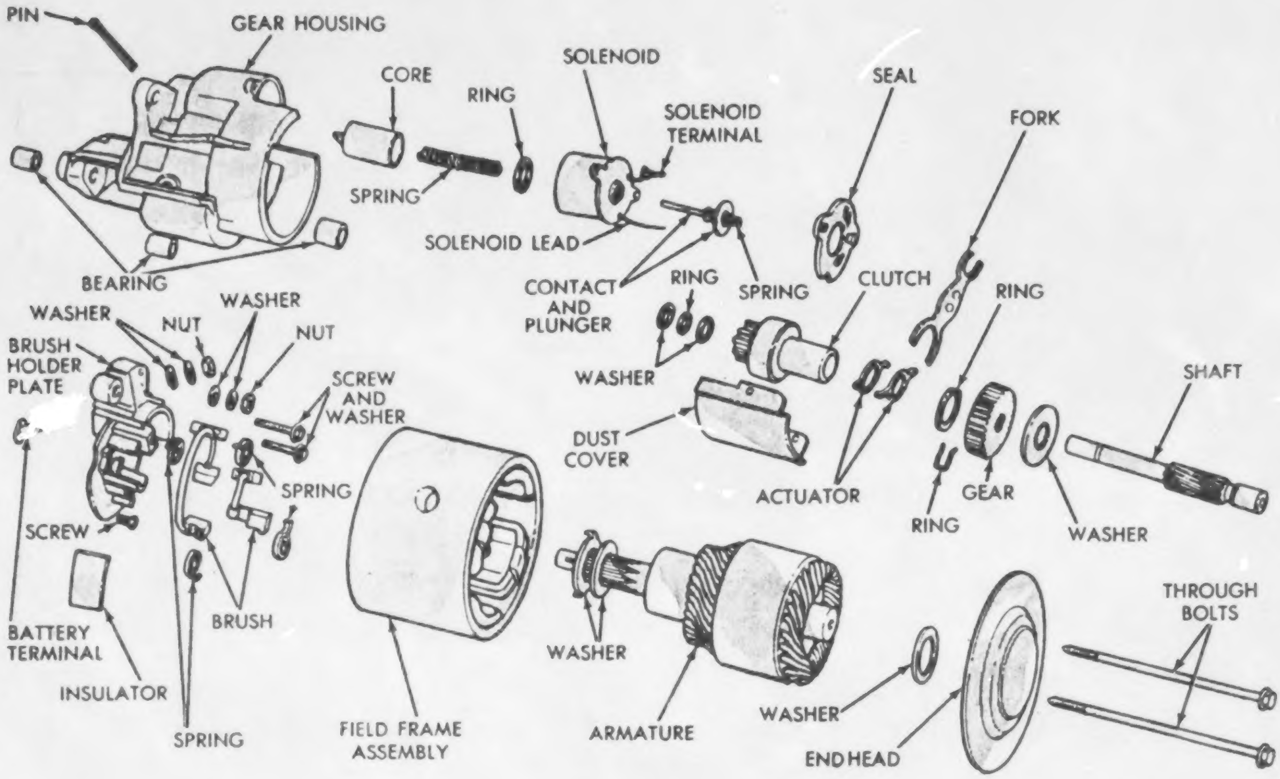

PIN
GEAR HOUSING
CORE
RING
SOLENOID
SOLENOID TERMINAL
SEAL
FORK
SPRING
SOLENOID LEAD
BEARING
CONTACT AND PLUNGER
RING
SPRING
CLUTCH
RING
WASHER
NUT
WASHER
NUT
BRUSH HOLDER PLATE
SCREW AND WASHER
WASHER
DUST COVER
ACTUATOR
SHAFT
SPRING
GEAR
RING
WASHER
SCREW
BATTERY TERMINAL
INSULATOR
BRUSH
SPRING
FIELD FRAME ASSEMBLY
WASHER
ARMATURE
WASHER
END HEAD
THROUGH BOLTS

Fig. 20—Starter Motor (Exploded View)

Assembling the Starter (Fig. 20)

The shifter fork consists of two spring steel plates assembled with two rivets. There should be approximately 1/16 inch side movement as shown in Figure 21 to insure proper pinion gear engagement. Lubricate between the plates sparingly with SAE 10 engine oil.

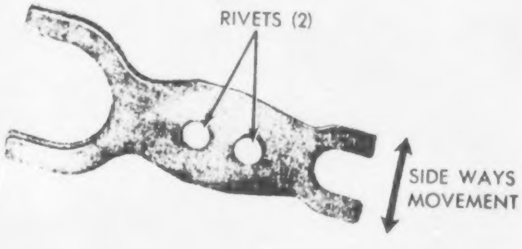

RIVETS (2)
SIDE WAYS MOVEMENT

Fig. 21—Shifter Fork

1. Position shifter fork in drive housing and install shifting fork retainer pin. One tip of pin should be straight, other tip should be bent at a 15 degree angle away from the housing. The fork and retainer pin should operate freely after bending tip of pin
2. Install solenoid moving core and engage shifting fork (Fig. 18)
3. Enter pinion shaft into drive housing and install friction washer and drive gear.
4. Install clutch and pinion assembly, thrust washer, retaining and thrust wash (Fig. 17)
5. Complete installation of pinion shaft, engaging shifting fork with clutch actuators. Figures 21 and 22 show correct relation of parts at assembly. The friction washer must be positioned on shoulder of splines of the pinion shaft before driven gear is positioned.
6. Install driven gear snap ring (Fig. 14)

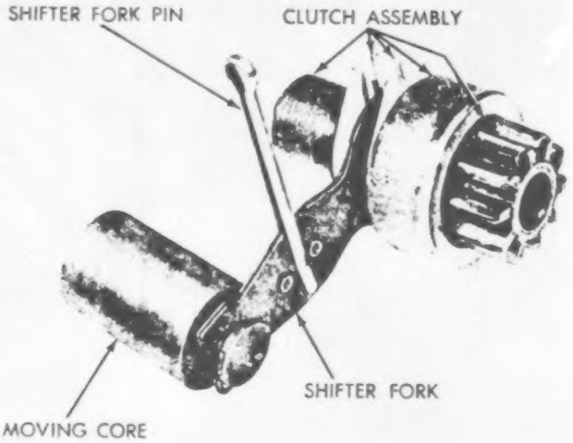


Fig. 22–Shifter Fork and Clutch Arrangement

7. Install pinion shaft "C" clip (Fig. 15)
8. Install starter solenoid return spring into bore of movable core. Inspect condition of starter solenoid switch contacting washer, if top of washer is burned from arcing, disassemble contact switch plunger assembly and reverse the washer.
9. Install solenoid contact plunger assembly into solenoid. Make sure contact spring is positioned on the shaft of the solenoid contact plunger assembly.
10. Assemble battery terminal stud in brush holder. Inspect condition of the contacts in brush holder plate. If contacts are badly burned, replace brush holder with brushes and contacts as an assembly.
11. Position seal on brush holder plate.

12. Enter solenoid lead wire through hole in brush holder (Fig.23) and install solenoid stud, insulating washer, flat washer and nut.
13. Wrap solenoid lead wire tightly around brush terminal post as shown in Figure 24 and solder securely with a high temperature resin core solder and resin flux.
14. Install brush holder to solenoid attaching screws.

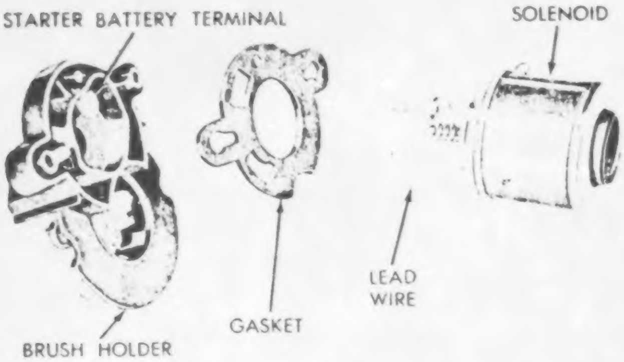


Fig.23–Assembling Solenoid to Brush Holder Plate

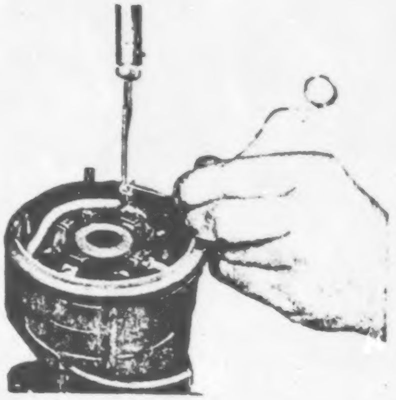


Fig. 24–Soldering Solenoid Lead to Brush Terminal

15. Carefully enter solenoid coil and brush plate assembly into bore of gear housing and position brush plate assembly into starter gear housing (Fig.25) and install housing attaching nuts. Tighten securely.

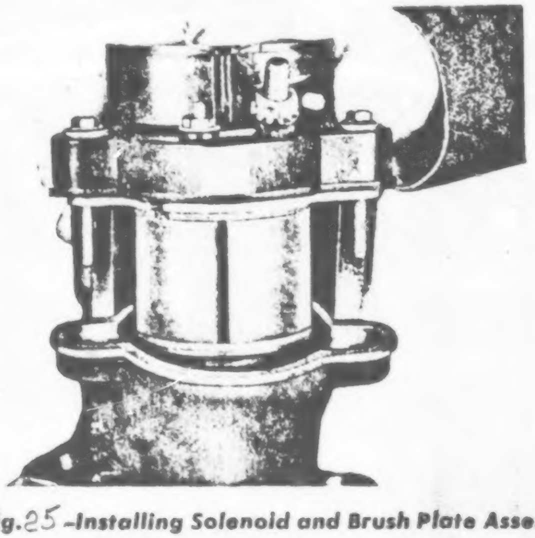


Fig.25 –Installing Solenoid and Brush Plate Assembly

16. Position brushes with armature thrust washer as shown in Figure 26. This will hold brushes out and facilitate proper installation of armature.
17. Install brush terminal screw (Fig. 3).
18. Position field frame to the exact position on gear housing and enter armature into field frame and starter gear housing (Fig. 27) carefully engaging splines of shaft with reduction gear by rotating armature slightly to engage the splines.
19. Install thrust washer on armature shaft.
20. Position starter end head assembly and install through bolts. Tighten through bolts securely.

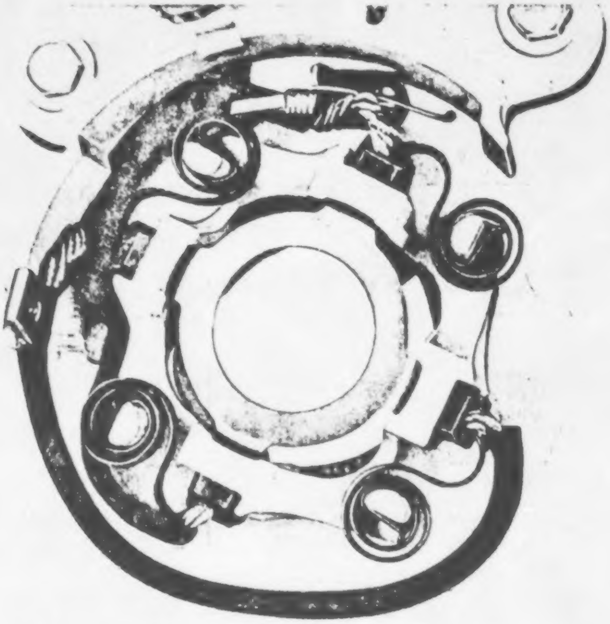


Fig. 26—Positioning Armature Thrust Washers to Brushes

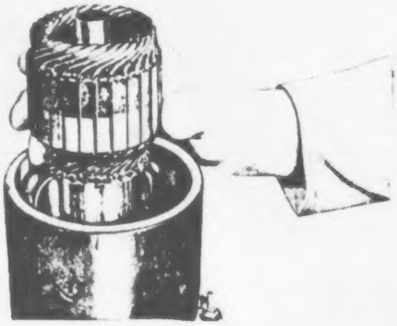


Fig. 27 -Installing Armature

Electrical Competencies - Cranking System

No. D-9 Disassemble, Test, Repair and Assemble Cranking Motors

Information Sheet # 4

Fords Movable Pole Type Starter

Use the following procedure when it becomes necessary to completely overhaul the starter, Fig. 1 illustrates a partially disassembled starter.

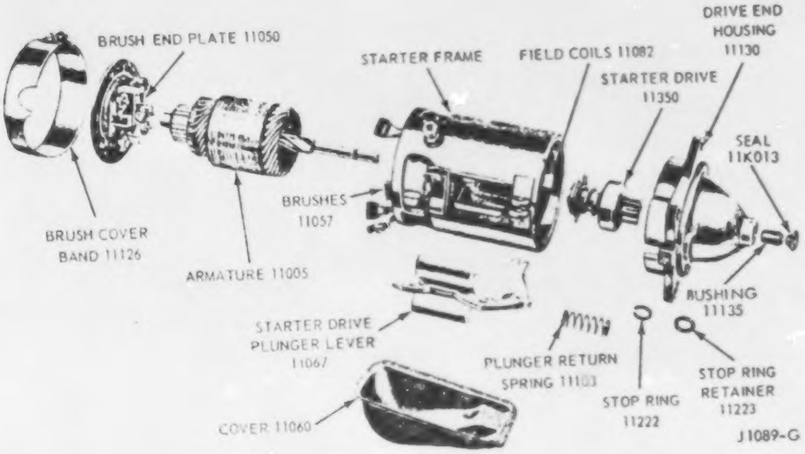

BRUSH END PLATE 11050
STARTER FRAME
FIELD COILS 11082
DRIVE END HOUSING 11130
STARTER DRIVE 11350
SEAL 11K013
BRUSHES 11057
BRUSH COVER BAND 11126
ARMATURE 11005
BUSHING 11135
STARTER DRIVE PLUNGER LEVER 11067
PLUNGER RETURN SPRING 11103
STOP RING 11222
STOP RING RETAINER 11223
COVER 11060
J1089-G

FIG. 1 Starter Disassembled

Disassembly

1. Loosen the brush cover band retaining screw and remove the brush cover band and starter drive plunger lever cover. Observe the lead positions for assembly and then remove the commutator brushes from the brush holders.

2. Remove the through bolts, starter drive end housing, and the starter drive plunger lever return spring.

3. Remove the pivot pin retaining the starter gear plunger lever and remove the lever and the armature.

4. Remove the stop ring retainer. Remove and check the stop ring retaining the starter drive gear to the end of the armature shaft, and remove the starter drive gear assembly.

5. Remove the brush end plate.

6. Remove the two screws retaining the ground brushes to the frame.

7. On the field coil that operates the starter drive gear actuating lever, bend the tab up on the field coil retaining sleeve and remove the sleeve.

8. Remove the three coil retaining screws, using tool 10044-A and an arbor press (Fig. 2). The arbor press prevents the wrench from slipping out of the screw. Unsolder the field coil leads from the terminal screw, and remove the pole shoes and coils from the frame. Use a 300-watt iron.

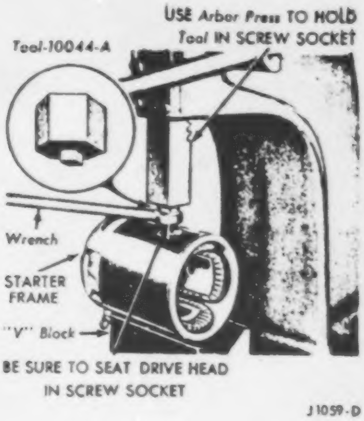

USE Arbor Press TO HOLD Tool IN SCREW SOCKET
Tool-10044-A
Wrench
STARTER FRAME
"V" Block
BE SURE TO SEAT DRIVE HEAD IN SCREW SOCKET
J1059-D

FIG. 2 Pole Shoe Screw Removal

9. Cut (or unsolder) the insulated brush leads from the field coils, as close to the field connection point as possible.

10. Remove the starter terminal nut, washer, insulator and terminal from the starter frame. Remove any excess solder from the terminal slot.

Cleaning and Inspection

1. Use a brush or air to clean the field coils, armature, commutator, armature shaft, brush end plate, and drive end housing. Wash all other parts in solvent and dry the parts.

2. Inspect the armature windings for broken or burned insulation and unsolder connections.

3. Check the armature for open circuits and grounds.

4. Check the commutator for runout (Fig. 3). Inspect the armature shaft and the two bearings for scoring and excessive wear. If the commutator is rough, or more than 0.005 inch out-of-round, turn it.

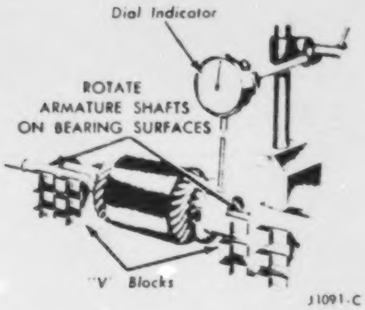


FIG. 3 Commutator Runout Check

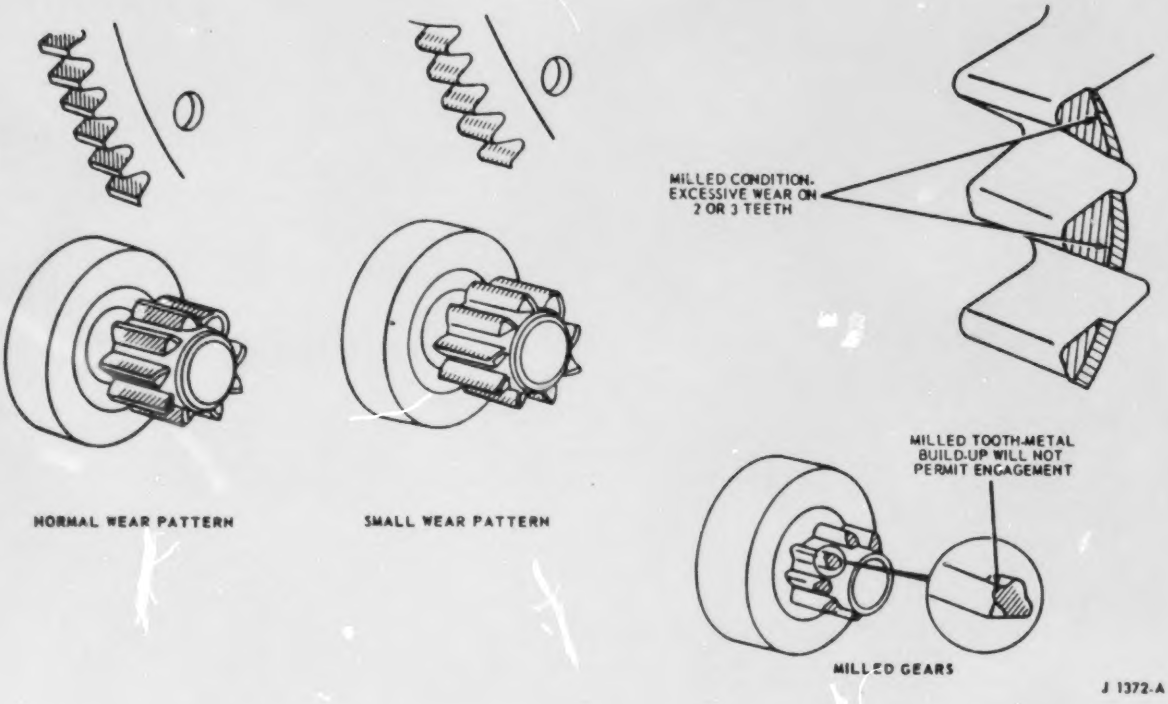
5. Check the brush holders for broken springs and the insulated brush holders for shorts to ground. Tighten any rivets that may be loose. Replace the brushes if worn to ½ inch in length.

6. Check the brush spring tension. Replace the springs if the tension is not within specified limits (40 ounces minimum).

7. Inspect the field coils for burned or broken insulation and continuity. Check the field brush connections and lead insulation. A brush kit and a contact kit are available. All other assemblies are to be replaced rather than repaired.

8. Examine the wear pattern on the starter drive teeth. The pinion teeth must penetrate to a depth greater than 1/2 the ring gear tooth depth (Fig. 4), to eliminate premature ring gear and starter drive failure.

9. Replace starter drives and ring gears with milled, pitted or broken teeth or that show evidence of inadequate engagement (Fig. 4).


MILLED CONDITION. EXCESSIVE WEAR ON 2 OR 3 TEETH
MILLED TOOTH-METAL BUILD-UP WILL NOT PERMIT ENGAGEMENT
J 1372-A

NORMAL WEAR PATTERN

SMALL WEAR PATTERN

MILLED GEARS

FIG. 4 Pinion and Ring Gear Wear Patterns

Assembly

1. Install The starter terminal, insulator, washers, and retaining nut in the frame (Fig. 5). Be sure to position the slot in the screw perpendicular to the frame end surface.

2. Position the coils and pole pieces, with the coil leads in the terminal screw slot, and then install the retaining screws (Fig. 2). As the pole shoe screws are tightened, strike the frame several sharp blows with a soft-faced hammer to seat and align the pole shoes, then stake the screws.

3. Install the solenoid coil and retainer and bend the tabs to retain the coils to the frame.

4. Solder the field coils and solenoid wire to the starter terminal using rosin core solder. Use a 300-watt iron.

5. Check for continuity and grounds in the assembled coils.

6. Position the new insulated field brushes lead on the field coil terminal. Install the clip provided with the brushes to hold the brush lead to the terminal. Solder the lead, clip, and terminal together, using rosin core solder (Fig. 5). Use a 300-watt iron.

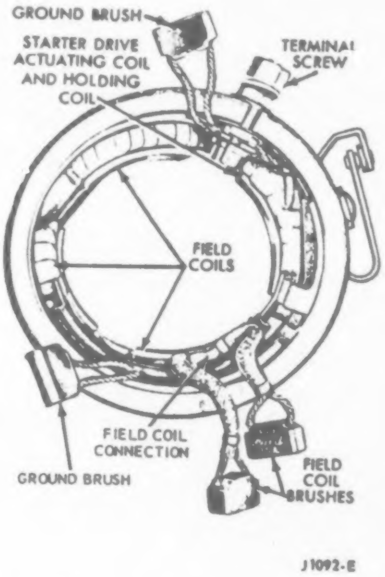

GROUND BRUSH
STARTER DRIVE ACTUATING COIL AND HOLDING COIL
TERMINAL SCREW
FIELD COILS
FIELD COIL CONNECTION
GROUND BRUSH
FIELD COIL BRUSHES
J1092-E

FIG. 5 Field Coil Assembly

7. Position the solenoid coil ground terminal over the nearest ground screw hole.

8. Position the ground brushes to the starter frame and install the retaining screws (Fig. 5).

9. Position the starter brush end plate to the frame with the end plate boss in the frame slot.

10. Apply a thin coating of Lubriplate 777 on the armature shaft splines. Install the starter motor drive gear assembly to the armature shaft and install a new retaining stop ring. Install a new stop-ring retainer.

11. Position the fiber thrust washer on the commutator end of the armature shaft and position the armature in the starter frame.

12. Position the starter drive gear plunger lever to the frame and starter drive assembly, and install the pivot pin.

13. Partially fill the drive end housing bearing bore with grease (approximately 1/4 full). Position the starter drive plunger lever return spring and the drive end housing to the frame and install and tighten the through bolts to specification (55-75 inch pounds). Do not pinch the brush leads between the brush plate and the frame. Be sure that the stop ring retainer is seated properly in the drive housing.

14. Install the brushes in the brush holders. Be sure to center the brush springs on the brushes.

15. Position the drive gear plunger lever cover on the starter and install the brush cover band with a gasket. Tighten the band retaining screw.

16. Check the starter no- load current draw.

Starter Drive Replacement

1. Loosen and remove the brush cover band and the starter drive plunger lever cover (Fig. 1).

2. Loosen the through bolts enough to allow removal of the drive end housing and the starter drive plunger lever return spring.

3. Remove the pivot pin retaining the starter drive plunger lever and remove the lever.

4. Remove the drive gear stop ring retainer and stop ring from the end of the armature shaft and remove the drive gear assembly.

5. Apply a thin coating of Lubriplate 777 on the armature shaft splines. Install the drive gear assembly on the armature shaft and install a new stop ring.

6. Position the starter gear plunger lever on the starter frame and install the pivot pin. Be sure that the plunger lever properly engages the starter drive assembly.
7. Install a new stop-ring retainer. Partially fill the drive end housing bearing bore with grease (approximately 1/4 full). Position the starter drive plunger lever return spring and drive end housing to the starter frame, and then tighten the through bolts to specifications (55-75 inch pounds).
8. Position the starter drive plunger lever cover and the brush cover band, with its gasket, on the starter. Tighten the brush cover band retaining screw.

Brush Replacement

Replace the starter brushes when they are worn to 1/4 inch. Always install a complete set of new brushes.

1. Loosen and remove the brush cover band, gasket, and starter drive plunger lever cover. Remove the brushes from their holders.
2. Remove the two through bolts from the starter frame.
3. Remove the drive end housing, and the plunger lever return spring.
4. Remove the starter drive plunger lever pivot pin and lever, and remove the armature.
5. Remove the brush end plate.
6. Remove the ground brush retaining screws from the frame and remove the brushes.
7. Cut the insulated brush leads from the field coils, as close to the field connection point as possible.
8. Clean and inspect the starter motor.
9. Replace the brush end plate if the insulator between the field brush holder and the end plate is cracked or broken.
10. Position the new insulated field brushes lead on the field coil connection. Position and crimp the clip provided with the brushes to hold the brush lead to the connection. Solder the lead, clip, and connection together, using rosin core solder (Fig. 5). Use a 300-watt iron.
11. Install the ground brush leads to the frame with the retaining screws.
12. Clean the commutator with 00 or 000 sandpaper.
13. Position the brush end plate to the starter frame, with the end plate boss in the frame slot.

14. Install the armature in the starter frame.

15. Install the starter drive gear plunger lever to the frame and starter drive assembly, and install the pivot pin.

16. Partially fill the drive end housing bearing bore with grease (approximately 1/4 full). Postion the return spring on the plunger lever, and the drive end housing to the starter frame. Install the through bolts and tighten to specified torque (55-75 inch pounds). Be sure that the stop ring retainer is seated properly in the drive end housing.

17. Install the commutator brushes in the brush holders. Center the brush springs on the brushes.

18. Position the plunger lever cover and the brush cover band, with its gasket, on the starter. Tighten the band retaining screw.

19. Connect the starter to a battery to check its operation.

Armature Replacement

1. Loosen the brush cover band retaining screw and remove the brush cover band, gasket, and the starter drive plunger lever cover. Remove the brushes from their holders.

2. Remove the through bolts, the drive end housing, and the drive plunger lever return spring.

3. Remove the pivot pin retaining the starter gear plunger lever, and remove the lever.

4. Remove the armature. If the starter drive gear assembly is being reused, remove the stop ring retainer and the stop ring from the end of the armature shaft, and remove the drive.

5. Place the drive gear assembly on the new armature with a new armature with a new stop ring.

6. Install the armature in the starter frame.

7. Position the drive gear plunger lever to the frame and drive gear assembly and install the pivot pin.

8. Partially fill the drive end housing bearing bore with grease (approximately 1/4 full). Position the drive plunger lever return spring, the drive end housing and the front end plate to the starter frame, and then install and tighten the through bolts to specification. Be sure that the stop ring retainer is seated properly in the drive housing.

9. Place the brushes in their holders, and center the brush springs on the brushes.

10. Position the plunger lever cover and the brush cover band, with its gasket, and then tighten the retaining screw.

11. Connect the starter to a battery to check its operation.

Starter Terminal

Removal

1. Loosen the brush cover band retaining screw and remove the brush cover and the starter drive plunger lever cover. Observe the lead positions for assembly and then remove the commutator brushes from the brush holders.

2. Remove the through bolts, starter drive end housing, starter drive plunger lever return spring, and the brush end plate.

3. Remove the pivot pin retaining the starter gear plunger lever and remove the lever and the armature assembly.

4. Unsolder the field coil and solenoid wire leads from the terminal screw. Use a 300-watt soldering iron.

Remove the starter terminal nut, washer, insulator and terminal from the starter frame.

Installtion

1. Install the new starter terminal, insulator, washer, and retaining nut in the frame (Fig. 1). Be sure to position the slot in the screw perpendicular to the frame end surface.

2. Solder the field coils and solenoid wire to the starter terminal using rosin core solder. Use a 300-watt iron.

3. Check for continuity and grounds in the assembled coils.

4. Position the starter brush end plate to the frame with the end plate boss in the frame slot.

5. Position the armature in the starter frame.

6. Position the starter drive gear plunger lever to the frame and starter drive assembly, and install the pivot pin.

7. Partially fill the drive end housing bearing bore with grease (approximately 1/4 full). Position the starter drive plunger lever return spring and the drive end housing to the frame and install and tighten the through bolts to specification (55-75 in-lbs). Do not pinch the brush leads between the brush plate and the frame. Be sure that the stop ring retainer is seated properly in the drive housing.

8. Install the brushes in the brush holders. Be sure to center the brush springs on the brushes.

9. Position the drive gear plunger lever cover on the starter and install the brush cover band with a gasket. Tighten the band retaining screw.

10. Check the starter no-load current draw.

Electrical Competencies- Cranking System

No. D-9 Disassemble, Test, Repair, and
Assemble Cranking Motors

Worksheet #1

Name ______________________ Date __________ Grade ________

1. Armatures are tested for __________ and ____________.

2. The machine used to test the armature for shorts is called ____________.

3. A ______________ is used to check the armature for grounds.

4. One test light lead is placed on the insulated brush, the other lead is touched to the field connector. If the test lamp lights the field coils are:
   a. grounded
   b. open
   c. field coils are OK
   d. A and C above

5. With one test lead placed on the connector bar (insulated brush) and the other test lead on the grounded brush, the test light does not light. The field coils are:
   a. grounded
   b. open
   c. field coils are OK
   d. shorted

6. When turning a commutator on a lathe care must be taken not to cut beyond the section previously __________________.

7. The mica insulation should be undercut to a depth of ________ inch.

8. After undercutting, the slots should be cleaned out carefully to remove any __________________ and ______________________.

9. It is not necessary to undercut the material between the bars of a ____________________ commutator.

10. After turning the commutator the armature should be rechecked on the ___________________ for shorts.

11. The bolts holding the commutator end frame, field frame assembly and drive housing together are called __________________ bolts.

12. On the G.M. type starter, what tool is used to remove the retainer on the armature shaft? ____________________________________

13. On the intermediate model, G.M. type starter the solenoid, lever housing, and nose housing should be _____________ to ease assembly.

14. On the intermediate models, before the armature is removed from the lever housing the ______________ has to be removed from the armature shaft.

15. Do not use grease dissolving solvent for cleaning the ______________, ______________, and ______________ since such a solvent would dissolve the grease packed in the clutch mechanism and would damage armature and field coil insulation.

Electrical Competencies- Cranking System

No. D-9 Disassemble, Test, Repair, and
Assemble Cranking Motors

Worksheet #1
Page 2

16. If the brushes are pitted or worn to ____________ their original length, they should be replaced.

17. What type of lubricant should be used on starter bushings.

____

18. What condition would dictate that the commutator should be turned? If it is ____________, ____________, or ____________.

19. What is used to start the snap ring on the upper end of the armature shaft?

____

20. A special ________ ________ should be used between the frame and ____________ case.

21. What are the pinion clearance specifications? ____________
How many thousandths in one-eighth (1/8) inch? ____________

22. Before the solenoid is removed from a Chrysler starter brush plate the solenoid ________ ________ has to be ________ from the brush plate.

23. The retainer clip (Chrysler) that positions the driven gear on the pinion shaft is under ________ and precautions have to be taken before disassembly.

24. Test starter bushings for wear by inserting the shafts and test for

________ ________.

25. (Chrysler) All gear reduction motor bushings can be replaced with the exception of the ________ ________ bushing. Where is it located?

____

26. The starter clutch outer housing and pinion gear may be cleaned with ____________ moistened with a ________ ________ and ________ dry with a clean dry cloth.

27. (Chrysler) There should be ____________ inch side movement between the shifter fork and gear housing.

28. (Chrysler) The friction washer must be positioned on the ________ ________ ___ ___ ________ of the pinion shaft before the ________ ________ is positioned.

29. (Chrysler) If the ____ ________ contacts are badly burned, replace brush holder with brushes and contacts as an assembly.

30. (Chrysler) Wrap solenoid lead wire tightly around brush terminal post and ________ securely with a high temperature ________ core solder.

31. (Chrysler) To facilitate proper installation of armature position brushes with the ______________ ______________ ______________. NOTE: Look at Fig. 26.

32. (Ford) A ______________ kit and a ____________ kit are available, all other assemblies are to be replaced rather than repaired.

33. The starter drive teeth must penetrate to a depth greater than ____________ the ring gear tooth depth, to eliminate premature ring gear and starter drive failure.

34. (Ford) When installing the starter terminal screw, insulator, washers and retaining nut in the starter frame be sure to position the ______________ in the screw perpendicular (90°) to the ______________ ______________ surface.

35. Ford suggests applying a thin coating of ______________ on the armature shaft splines.

36. (Ford) Partially fill the drive end housing bearing bore with grease, approximately ___________ full.

37. (Ford) Replace the starter brushes when they are worn to ____________ inch.

38. (Ford) A ___________ ____________ should be used when removing the field coil retaining screws.

39. When soldering starter wire connections a ____________ watt solding iron should be used.

40. (Ford) If the commutator is rough, or more than _________ inch out-of-round, turn it.

Electrical Competencies - Cranking System

No. D-9 Disassembly, Test, Repair and Assemble Cranking Motor

Worksheet # 2

Name ______________________________ Date ____________ Grade ________

GM Type Starter

Disassembly

1. Disconnect field coil connector from motor solenoid terminal.
2. Remove through bolts
3. Remove commutator end frame, field frame assembly, armature assembly.
4. Remove overrunning clutch from armature shaft refer to Information Sheet D-9 page
5. Disassemble brush rigging from field frame refer to Information Sheet D-9 page

Instructor's Initials ____________

Visual Inspection of Starter

	Yes	No
A. Burned, charred or cracked insulation	________	________
B. Thrown solder	________	________
C. Dirty, worn, burned or glazed commutator	________	________
D. Burned, cracked or loose terminal insulation	________	________
E. Loose commutator bars	________	________
F. Bruised armature core laminations	________	________
G. Worn armature shaft, bushing or bearings	________	________
H. Loose or improperly installed pole shoes	________	________
I. Loose brush holders	________	________
J. Bent or misaligned brush holders	________	________
K. Broken or weak brush holder springs	________	________
L. Worn, oily or dirty brushes	________	________
M. Improper brushes	________	________
N. Starter drive teeth worn	________	________
O. Free starter drive movement	________	________

Electrical Competencies - Cranking System

No. D-9 Disassembly, Test, Repair and Assemble Cranking Motor

Worksheet # 2
Page 2

Starter Component Checks

A. Armature Tests

Short ______Good ________Bad

Ground ______Good ________Bad

Coil Balance ______Good ________Bad

Commutator Condition ______Good ________Bad

Turn Armature ______Good ________Bad

Note: See instructor for armature turning procedures.

B. Field Coil And Brush Holder Tests

Ground ______Good ________Bad

Continuity ______Good ________Bad

C. Brush Condition ______Good ________Bad

D. Bushing Condition ______Good ________Bad

Instructor's Initials ____________

Assembly

1. Assemble brush rigging to field frame.
2. Assemble overrunning clutch assembly to armature shaft.
3. Lubricate drive housing bushing. Make sure thrust collar is in place against snap ring and retainer and slide armature and clutch assembly into place in drive housing engaging shift lever with clutch.
4. Position field frame over armature and position it against drive housing.
5. Lubricate the bushing in the commutator end frame. Place leather washer on armature shaft and slide commutator end frame onto shaft.
6. Reconnect field coil connections.

Instructor's Initials____________

Note: Check starter by performing the no load test competency D-10.

Electrical Competancies - Cranking System

No. D-9 Disassemble, Test, Repair and Assemble Cranking Motors

Worksheet # 3

Name ______________________ Date __________ Grade __________

Chrysler Type Starter

Disassembly

1. Remove through bolts and end assembly.
2. Remove armature.
3. Pul field frame assembly from gear housing far enough to expose terminal screw.
4. Remove terminal screw.
5. Remove field frame assembly.
6. Remove nuts attaching solenoid and brush holder plate assembly to gear housing.
7. Remove solenoid and brush plate assembly from housing.
8. Remove nut, stell washer, and sealing washer from solenoid terminal.
9. Unwind solenoid lead wire from brush terminal.
10. Remove screws attaching solenoid in brush plate.
11. Remove solenoid from brush plate.
12. On brush plate remove nut from battery terminal and remove terminal.
13. Remove solenoid contact and plunger.
14. Remove return spring.
15. Remove dust cover from gear housing.
16. Release retainer clip that positions driven gear on pinion shaft.
17. Remove pinion shaft.
18. Remove retainer ring, thrust washer, clutch assembly.
19. Remove driven gear and friction washer.
20. Remove solenoid moving core.
21. Remove shigting fork retainer and fork assembly.

Instructor's Initials __________

Visual Inspection of Starter		Yes	No
A.	Burned, charred or cracked insulation		
B.	Thrown solder		
C.	Dirty, worn, burned or glazed commutator		
D.	Burned, cracked or loose terminal insulation		
E.	Loose commutator bars		
F.	Bruised armature core lamination		
G.	Worn armature shaft, burshings or bearings		
H.	Loose or improperly installed pole shoes		
I.	Loose brush holders		
J.	Bent or misaligned brush holders		
K.	Broken or weak brush holder springs		
L.	Worn, oily or dirty brushes		
M.	Improper brushes		
N.	Starter drive teeth worn		
O.	Free starter drive movement		

Electrical Competencies - Cranking System

No. D-9 Disassemble, Test, Repair and Assemble Cranking Motor

Worksheet # 3
Page 2

Starter Component Checks

A. Armature Tests

Short ________good ________bad
Ground ________good ________bad
Coil Balance ________good ________bad
Commutator Condition ________good ________bad
Turn Armature ________good ________bad

Note: See instructor for procedures on armature turning.

B. Field coil and brush holder tests

Ground ________good _______bad
Continuity ________good _______bad
Brush Condition ________good _______bad
Bushing Condition ________good _______bad

Instructor's Initials_________

Assembly

1. Position shifter fork in drive housing and install shifting fork retainer pin.
2. Install solenoid moving core and engage shifting fork.
3. Enter pinion shaft into drive housing and install friction washer and drive gear.
4. Install clutch and pinion assembly, thrush washer.
5. Complete installation of pinion shaft, engaging shifting fork with clutch actuators.
6. Install driven gear snap ring.
7. Install pinion shaft C clip.
8. Install starter solenoid return spring into bore of movable core.
9. Install solenoid contact plunger assembly.
10. Assemble battery terminal stud in brush holder.
11. Position seal on brush holder plate.
12. Enter solenoid lead wire through hole in brush holder and install solenoid stud, insulating washer, flat washer and nut.
13. Wrap solenoid lead wire tightly around brush terminal post and solder securely.
14. Install brush holder to solenoid attacing screws.
15. Carefully enter solenoid coil and brush plate assembly into bore of gear housing and install attaching nuts.
16. Position brushes with armature thrust washer
17. Install brush terminal screw.
18. Position field frame to exact position on gear housing.
19. Install thrust washer on armature shaft.
20. Position starter end head assembly and install through bolts.

Instructor's Initials__________

Note: Check starter by performing the no load test competency D-10.

Electrical Competencies - Cranking System

No. D-9 Disassembly, Test, Repair and Assembly Cranking Motor

Worksheet # 4

Name ________________________________ Date _____________ Grade ___________

Fords Movable Pole Type Starter

Disassembly

1. Remove the brush cover band and starter drive plunger lever cover.
2. Remove the commutator brushes from brush holders.
3. Remove the through bolts, starter drive end housing, starter drive plunger lever return spring.
4. Remove the pivot pin retaining the starter gear plunger lever and remove the lever and the armature.
5. Remove the stop ring retainer. Remove the stop ring and slide the drive off the armature.
6. Remove brush end plate.
7. Remove the two screws retaining the ground brushes to the frame.
8. Cut (or unsolder) the insulated brush leads from the field coils.
9. Remove the starter terminal nut, washer, insulator and terminal from the starter frame.

Instructor's Initials ____________

Visual Inspection Of Starter	Yes	No
A. Burned, charred or cracked insulation	_____	_____
B. Thrown solder	_____	_____
C. Dirty, worn, burned or glazed commutator	_____	_____
D. Burned, cracked, or loose terminal insulation	_____	_____
E. Loose commutator bars	_____	_____
F. Bruised armature core laminations	_____	_____
G. Worn armature shaft, bushing or bearings	_____	_____
H. Loose or improperly installed pole shoes	_____	_____
I. Loose brush holders	_____	_____
J. Bent or misaligned brush holders	_____	_____
K. Broken or weak brush holder springs	_____	_____
L. Worn, oily, or dirty brushes	_____	_____
M. Improper brushes	_____	_____
N. Starter drive teeth worn	_____	_____
O. Free starter drive movement	_____	_____

Starter Component Checks

A. Armature Tests		
Short	_____good	_____bad
Ground	_____good	_____bad
Coil Balance	_____good	_____bad
Commutator Conditions	_____good	_____bad
Turn Armature	_____good	_____bad

Note: See instructor for armature turning procedures

Electrical Competencies - Cranking System

No. D-9 Disassemble, Test, Repair and Assembly Cranking Motor

B. Field coil and brush holder test
Ground ________good ________bad
Continuity ________good ________bad

C. Brush condition ________good ________bad
D. Bushing condition ________good ________bad

Instructor's Initials__________

Assembly

1. Install the starter terminal, insulator, washers, retaining nut.
2. Position the new insulated field brushes lead on the field coil terminal. Install the clip provided with the brushes. Solder the lead, clip, and terminal together.
3. Position the solenoid coil ground terminal over the nearest ground screw hole.
4. Position the ground brushes to the starter frame and install the retaining screws.
5. Position the starter brush end plate to the frame with the end plate boss in the frame slot.
6. Apply a thin coating of lubricant on the armature shaft splines. Install the drive assembly on to the armature shaft and install the retaining stop ring.
7. Position the fiber thrust washer on the commutator end of the armature shaft and position the armature in the starter frame.
8. Position the drive gear plunger lever to the frame and drive assembly, and install the pivot pin.
9. Lubricate drive end of armature. Position drive plunger lever return spring and the drive end housing to the frame and install and tighten the through bolts.
10. Install brushes in the brush holders
11. Position the drive gear plunger lever cover on the starter and install the brush cover band with a gasket.

Instructor's Initials ________

Note: Check starter by performing the no load test competency D-10.

AUTO MECHANICS

Electrical Competencies - Cranking System

No. D-10 No Load Test

OBJECTIVE: At the completion of this unit you will be able to properly connect a Battery-Starter Tester to a cranking motor and perform a No-Load Test.

EXPLANATION: After a cranking motor has been assembled it should be checked for proper operation before it is placed back on the vehicle. A No-Load test will do that by comparing amperage draw and voltage with factory specifications.

MATERIALS NEEDED: Fully charged 12-Volt battery
12-Volt starter
Manufactures specifications

TOOLS NEEDED: Battery-Starter tester (BST)

References	Do
#1. p. 22-43	1. Read reference assignment
#2. --	2. Read information sheet # 1
#3. p.653	3. Do worksheet #1
#4. p.392	4. Connect ammeter and rheostat in series with battery-to-solenoid "Bat" terminal.
#5. p. 172	5. Connect voltmeter across starter and use a mechanical tachometer to measure RPM.
#6. p.274	6. Energize starter by connecting battery negative terminal to starter frame.
#7. --	7. Adjust rheostat to give specified voltage and note ammeter, and tachometer readings.
#8. --	8. Check with instructor.

Electrical Cometencies - Cranking System

No.D-10 Disassembly, Test, Repair and Assemble
Cranking Motors

Information Sheet # 1

AFter repair or purchase of a cranking motor, and before it is installed on the vehicle, it should be tested on the bench for proper operation. The test that is used is called a Starter No-Load Test.

Secure the starter before making no-load connections. Violent starting torque and extreme no-load rpm can make the starter dangerous.

A tachometer may also be attached to the starter to check no-load rpm. Check current draw and rpm against apecifications.

Adjust the load control (rheostat) to the extreme clockwise setting to prevent any current flow through the ammeter.

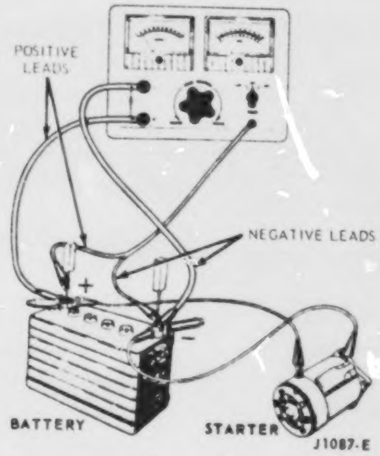


FIG. 1 Starter No-Load Test on Test Bench

Hook the starter up as shown(Fig. 1). While the starter is operating, note the EXACT voltmeter reading. Disconnect the starter and back off the load control until the voltmeter reading corresponds to that noted during starter no-load operation. At this point, the ammeter reading will indicate the no-load draw.

Speed and amperage at the specified voltage can be compared to specifications. Low readings indicate starter problems.

Some typical manufactures specifications for starter no-load test (Fig. 2).

POSITIVE ENGAGEMENT SPECIFICATIONS				
Dia. (Inches)	Normal Draw (Amps)	Normal Speed (RPM)	Max. Load (Amps)	No Load (Amps)
4 4½	150-200 150-180	180-250 150-290	460 670	70 80

Fig. 2

Some manufacturers give test specifications for no-load operation that require a specific voltage be applied to the starter and that the current draw at this EXACT voltage be measured.

A setup that can be used to test no-load rpm and current draw at a specifiec voltage is shown in Fig. 3.

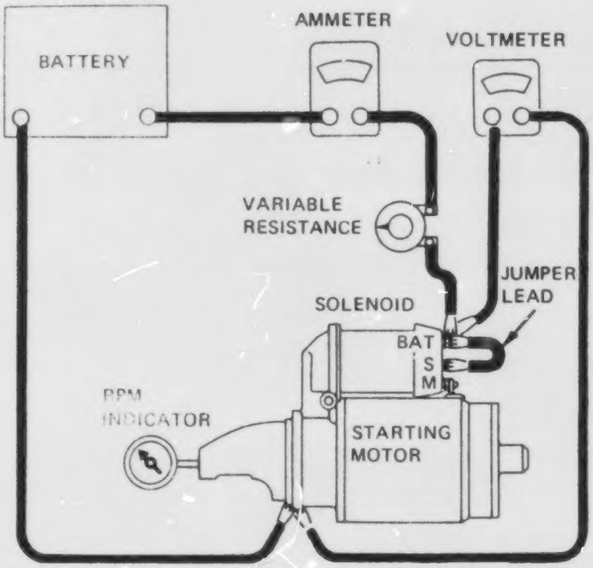


Fig. 3 No-load test of a starting motor. A jumper lead must be used, as shown, to energize the solenoid so that it operates to connect the starting motor to the battery. (*Delco-Remy Division of General Motors Corporation*)

Connect a test ammeter and carbon pile rheostat in series with battery positive post and starter terminal. Connect a voltmeter across starter. Rotate carbon pile to full resistance position. Connect battery cable from battery negative post to starter frame. Adjust rheostat until battery voltage shown on a voltmeter reads specification voltage. Amperage draw should be as shown in specifications.

Some typical specifications using a specified voltage during a no-load test are shown in Fig. 4 and 5.

STARTER PERFORMANCE SPECIFICATIONS					
Chrysler Starter No.	No Load Test			Lock Test	
	Volts	Amps.	RPM	Volts	Amps.
3656575	11	90max.	3700-4200	4.0	475-550

Fig. 4

DELCO-REMY STARTER SPECIFICATIONS			
Delco-Remy Number	No Load Test		
	Amps.①	RPM	Volts
1108195	50-75	6,500-10,000	9
1108196	50-75	6,500-10,000	9
1108224	65-95	7,500-10,000	9
1108225	37-75	6,000-9,000	9
1108226	37-75	6,000-9,000	9
1108365	50-80	5,500-10,500	9
1108400	65-95	7,500-10,500	9
1108418	65-95	7,500-10,500	9
1108429	65-95	7,500-10,500	9
1108430	65-95	7,500-10,500	9
1108436	65-95	7,500-10,500	9
1108498	55-80	3,500-6,000	9
1108500	37-75	6,000-9,000	9
1108506	55-80	3,500-6,000	9
1108507	45-80	4,000-6,000	9
1108516	55-80	3,500-6,000	9
1108517	45-80	4,000-6,000	9
1108518	65-95	7,500-10,000	9
1108521	65-95	7,500-10,000	9
1108522	65-95	7,500-10,000	9

① — Includes solenoid.

Fig. 5

If the starter is found to be faulty, it should be disassembled and each component checked for correct operation. This is called bench checking the starter. Many shops exchange starters for rebuilt units when tests show that malfunctions exist within the starter. It is a good practice to run the free speed and stall tests on any replacement starter to see that it functions correctly before installing it on a vehicle.

Electrical Competencies - Cranking System

No. D-10 No Load Test

Worksheet # 1

Name ______________________________ Date __________ Grade __________

Manufactures Specifications ____________ Volts

____________ Amps

____________ RPM

Your Readings

____________ Volts

____________ Amps

____________ RPM

Condition of starter ____________ good ____________ bad

Instructor's Initials ____________

AUTO MECHANICS

Electrical Competencies - Cranking System

No. D-11 Troubleshooting The Cranking System

OBJECTIVE: At the completion of this exercise you will be able to determine if a cranking ysytem problem lies in the battery, in the starter. in the wiring between them. or elsewhere.

EXPLANATION: Many conditions besides defects in the starter itself can result in poor cranking performance. This exercise will help you to develop the skills needed to pinpoint cranking system problems.

MATERIALS NEEDED: Automobile

TOOLS NEEDED:

References	Do
#1. --	1. Read assigned references.
#2. --	2. Read information sheets.
#3. p. 638-640	3. Check with instructor (Be prepared for an oral quiz on information sheet.)
#4. p 391	
#5. --	
#6. p. 273-274	4. Complete written worksheet #1.
#7. p. 238-239	
#8. --	

Information Sheet # 1

TROUBLE-SHOOTING THE STARTING SYSTEM

The trouble-shooting of starting motors can be divided into two parts.

1. Tests made on the car when trouble occurs. These are to determine whether the starting motor or some other component is at fault.

2. Tests made on the starting motor after it has been removed from the engine.

NO CRANKING
SLOW CRANKING

TESTING THE STARTING MOTOR ON THE CAR

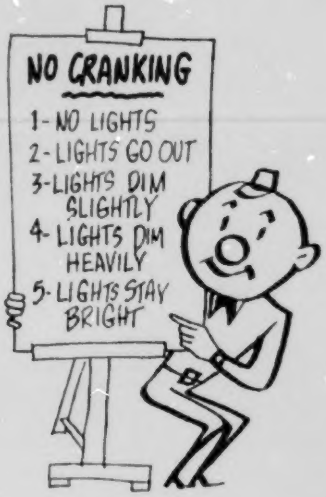
There are three basic starting-motor troubles:

1. The starting motor does not turn over.

2. The starting motor turns over slowly, but the engine does not start.

3. The starting motor turns over and cranks the engine at normal speed, but the engine does not start.

This last trouble cannot be blamed on the starting motor. If it spins the engine at normal cranking speed, it has done its job. There is some problem. in the fuel or ignition system, or the engine, that prevents starting. Let us look at the other two conditions.



THE STARTING MOTOR DOES NOT TURN OVER

The most likely cause here is a run-down battery. But there could be other causes. Turn on the headlights, and try cranking. There are five possibilities.

1. No cranking, no lights
   This is probably due to a completely dead battery. It could be caused by a bad connection at the battery or starting motor or an open fusible link (which indicates a short or ground in the system).

2. No cranking, lights go out as you close the starter switch
   If the lights go out as you close the starter switch, it is almost a sure sign of a bad connection at the battery. The bad connection lets only a little current through--enough for the lights to go on. But when you try to start, all the current goes to the starting motor because the starting motor has much less resistance than the lights. Therefore the lights go out.

3. No cranking, and lights dim only slightly as you try to start
   Chances are the trouble is in the starting motor. The pinion may be engaging with the flywheel. Or, there is an open circuit in the solenoid switch or starting motor. If the starting-motor armature spins, then the overrunning clutch is slipping.

4. No cranking, lights dim heavily when you try to start
   If the lights dim heavily when you try to start, the condition is most likely due to a run-down battery. The battery has enough charge to burn the lights, but not enough charge to deliver hundreds of amperes to the starting motor. Of course, you have to consider temperature, too. Low temperatures make it tough on the battery. The starting motor needs more current to start a cold engine. The battery should be in good condition and fully charged in the winter to assure good starting. There is one other thing to consider when you get no cranking and the lights dim heavily. You might have some sort of trouble in the starting motor or in the engine.

5. No cranking, and lights stay bright
Listen to hear if the solenoid is pulling the plunger in. You can hear this as a definite click. If nothing happens when you try to start, check the solenoid as follows: Connect one end of a jumper to the solenoid battery terminal. Connect the other end to the samll terminal on the switch that is connected to the ignition switch. If nothing happens, the trouble is in the solenoid. If the solenoid and starting motor work with the jumper connected, the trouble is in the ignition switch, the transmission switch, or the wires connecting them.

ENGINE CRANKS SLOWLY BUT DOES NOT START

This is very likely due to a run-down or defective battery. The battery is unable to spin the starting motor at normal speed. Low temperature could also be a factor here, as we noted in the previous section.

It is also possible that the driver may have run the battery down trying to start. That is, some condition in the engine, or the fuel or ignition system, is preventing normal starting. The driver continued to try, however, until the battery ran down.

The procedure here is to test the battery and replace or recharge it if it is low. Or connect a booster battery, and then try to start. See the caution below about using a booster battery. If the engine cranks normally and starts, the trouble is a low battery. If the engine cranks normally but does not start, the trouble is in the engine. If the engine still cranks slowly with a good battery, the trouble is in either the starting motor or engine.

CAUTION Use care in connecting a booster battery, to avoid hurting yourself or damaging the car's electrical equipment. Here is Ford's recommendation for using a jumper between two cars(for a negative-ground battery).

1. Remove the vent caps from both batteries. Cover the holes with cloths to prevent splashing of the electrolyte in case there is an explosion.

2. Shield your eyes.

3. Do not allow the two cars to touch each other.

4. Make sure all electrical equipment except the ignition is turned off on the car you are trying to start.

5. Connect the end of one cable to the positive (+) terminal of the booster battery. Conect the other end of this cable to the positive terminal of the dead battery.

6. Connect one end of the second cable to the negative (-) terminal of the booster battery.

7. Connect the other end of the second cable to the engine block of the car you are trying to start. Do not connect it to the negative (-) terminal of the car battery! This could damage electrical equipment.

8. Now start the car which has the booster battery. Then start the car which has the low battery. After the disabled car is started, disconnect the booster cables by first disconnecting the cable from the engine block. Then disconnect the other end of this (the negative) cable. Finally, disconnect the positive cable.

CAUTION Never operate the starting motor for more than 30 seconds at a time. Pause for a few minutes to allow it to cool off. They try again, if necessary. It takes a very high current to crank the engine. This can overheat the starting motor if it is used for too long a time. Overheating can ruin the starting motor.

The following chart can be used along with the above troubleshooting chart.

TROUBLESHOOTING: STARTING SYSTEM

TROUBLE: STARTER CRANKS ENGINE SLOWLY

Possible Cause

1. Discharged battery or defective cell.
2. Excessive resistance in starter.
3. Excessive resistance in cranking circuit.
4. Engine oil too heavy for prevailing temperature.
5. Excessive engine friction.

Correction

1. Make specific gravity and load tests. Recharge or replace battery.
2. Disassemble and check for bent armature, or armature dragging on field poles. Straighten or replace armature.
3. Make voltmeter or ohmmeter checks at cable connections, solenoid or relay, and at ground connections. Repair or replace units as required.
4. Change oil to suit conditions.
5. Check the tight-fitting engine bearings, pistons, rings, etc.

TROUBLE: STARTER INOPERATIVE

Possible Cause

1. Loose or corroded battery terminals.
2. Discharged battery.
3. Dead battery.
4. Open starting circuit.
5. Inoperative solenoid or relay.
6. Faulty ignition switch.
7. Defective starter.
8. Inoperative neutral safety switch (cars with automatic transmission).

Correction

1. Clean battery posts and cable clamps. Tighten clamps securely.
2. Recharge battery.

3. Replace battery.
4. Check cable connections, ignition switch, solenoid or relay and wiring. Repair as required.
5. Use heavy jumper cable to bypass unit. Replace faulty solenoid or relay.
6. Replace switch.
7. Disassemble starter and inspect parts. Repair or replace starter.
8. Check operation of switch. Adjust or replace switch.

TROUBLE: STARTER TURNS BUT DRIVE DOES NOT ENGAGE

Possible Cause

1. Broken teeth in flywheel ring gear.
2. Rusted starter drive shaft.
3. Defective starter drive.

Correction
1. Replace ring gear.
2. Clean, lubricate shaft.
3. Replace drive unit.

TROUBLE: STARTER DOES NOT DISENGAGE

Possible Cause

1. Faulty ignition switch.
2. Short circuit in solenoid.
3. Stuck solenoid contact switch plunger.
4. Broken solenoid plunger spring.
5. Faulty starter relay.

Correction

1. Replace switch.
2. Replace solenoid.
3. Repair solenoid.
4. Replace spring or solenoid
5. Replace relay.

Starting-Motor Repair

Repairing a starting motor is a job usually handled by a tune-up shop. As we noted earlier, most shops handle starter trouble by replacing the old starting motor with a new or rebuilt one. The major steps in rebuilding a starting motor are as follow:

Replace bushings supporting the armature.
Test the armature and the field coils.
Turn the commutator if required.
Replace the field coils if they are damaged.
Check the solenoid.
Replace the brushes.

To accomplish the above tasks refer to competency D-9.

Electrical Competencies - Cranking System

No. D-11 Troubleshooting The Cranking System

Worksheet # 1

Name ______________________________ Date __________ Grade ____________

Check the statement that best describes the operation fo the cranking motor.

A.________ Starter motor does not crank

B.________ Starter motor cranks slowly but engine does not start

C.________ Starter motor turns over and cranks the engine at normal speed, but the engine does not start.

MOTOR DOES NOT CRANK

A.________ No cranking,no lights

B.________ No cranking lights go out as you close the starter switch

C.________ No cranking, lights dim only slightly when you try to start

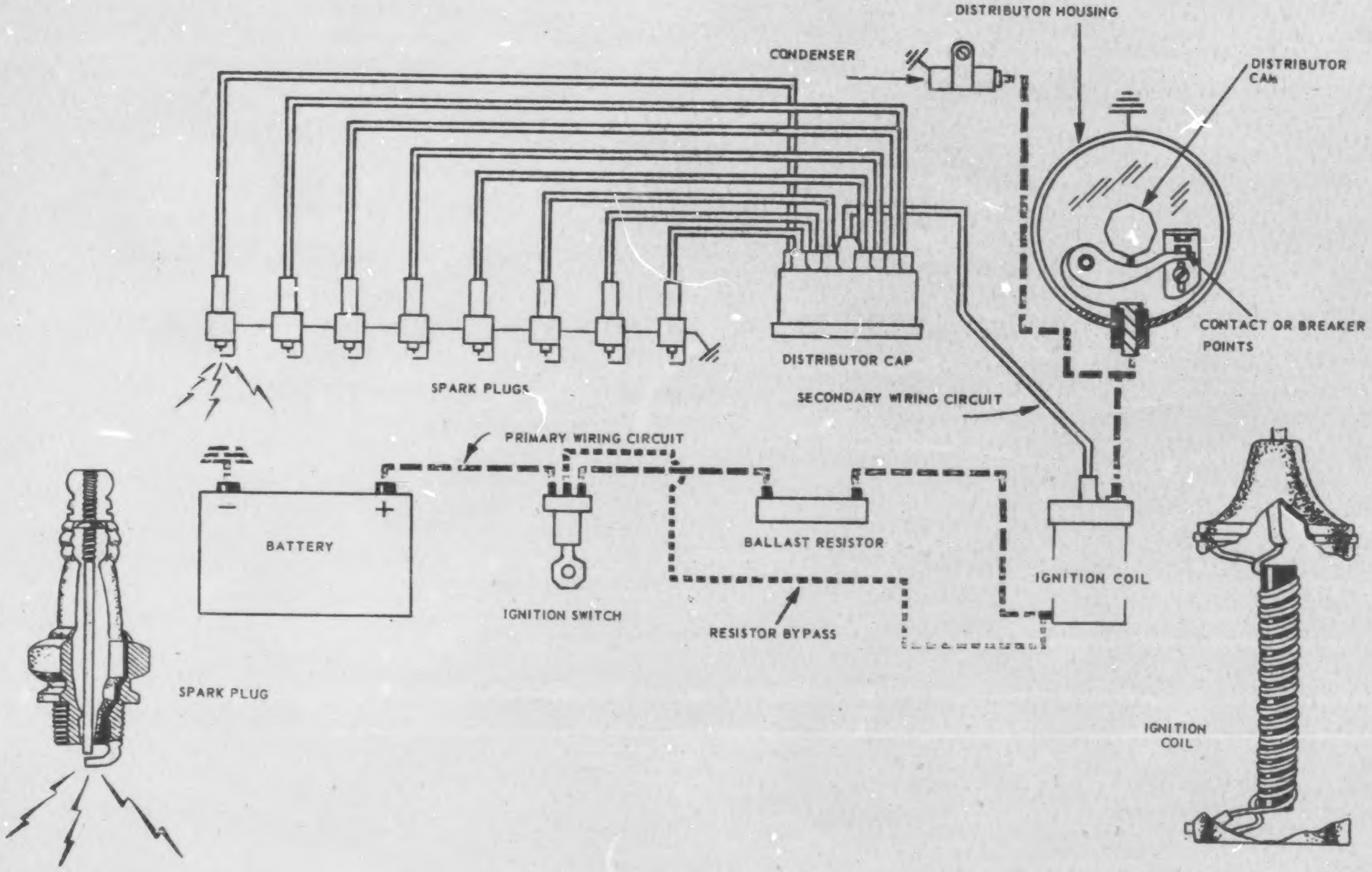
D.________ No cranking, lights dim heavily when you try to start

E.________ No cranking, lights stay bright when you try to start

Be prepared to explain to the instructor your diagnoses of the cranking system.

Instructor's Initials___________

The Ignition System


DISTRIBUTOR HOUSING
CONDENSER
DISTRIBUTOR CAM
CONTACT OR BREAKER POINTS
DISTRIBUTOR CAP
SPARK PLUGS
SECONDARY WIRING CIRCUIT
PRIMARY WIRING CIRCUIT
−
+
BATTERY
IGNITION SWITCH
BALLAST RESISTOR
RESISTOR BYPASS
IGNITION COIL
SPARK PLUG
IGNITION COIL

REFERENCE

The texts chosen were selected because they are in current use by the instructors who compiled this manual. You should have a copy of at least one in your shop.

The text books are to be used as references for each exercise in this book. For each exercise you will find a number followed by page numbers. Look up the book number on this list and the page numbers will correspond to the exercise you are working. For example if you find 5. 103-211 in the reference section you would check this reference list and find that book No. 5 is Auto Mechanics by H. E. Ellinger. In that book, pages 103-211 will apply to the exercise you are working.

	TEXT	AUTHOR	PUBLISHER
1.	Auto Service and Repair 1975	Stockel	Goodheart - Willcox
2.	Auto Mechanics Fundamentals 1974	Stockel	Goodheart - Willcox
3.	Motor Auto Engines and Electrical Systems 1975	Hearst Corporation	Motor
4.	Automotive Encyclopedia 1975	Tobotdt - Johnson	Goodheart - Willcox
5.	Auto Mechanics Second Edition	Ellinger	Prentice - Hall
6.	Automotive Mechanics	Crouse	McGraw - Hill
7.	The Auto Book	Crouse	McGraw - Hill
8.	Automotive Chassis And Accessory Circuits	Brezcha/Samuels	Prentice - Hall

Auto Mechanic's
Ignition System
No. E Index

E-1 Safety
E-2 Component
E-3 Circuit Identification
E-4 Testing- Visual Inspection
E-5 Testing- Battery, Cable, Ignition Switch and Circuit
E-6 Testing- Ballast Resistor and Bypass Circuit
E-7 Testing- Distributor
E-8 Testing- Coil
E-9 Testing- High Tension Leads
E-10 Testing- Cap and Rotor
E-11 Testing- Spark Plugs
E-12 Testing- Electronic Control Modules
E-13 Testing- Adjustments

SCHOOL ____________________ STUDENT ____________________

INSTRUCTOR ____________________ YEAR GRAD ____________________

AUTOMOTIVE ELECTRICAL COMPETENCIES-IGNITION SYSTEMS

	COMPETENCY	JR	M	C	SR	M	C	VOC	M	C	IND	M	C
E-1	Safety												
E-2	Component Identification												
E-3	Circuit Identification												
E-4	Testing-Visual Inspection												
E-5	Testing-Battery Cable, Ignition Switch and Circuit												
E-6	Testing-Ballast Resistor and Bypass Circuit												
E-7	Testing-Distributor												
E-8	Testing-Coil												
E-9	Testing- High Tension Leads												
E-10	Testing- Cap & Rotor												
1	Testing- Spark Plugs												
E-12	Testing- Electronic Control Modules												
E-13	Testing-Adjustments												
14													
15													
16													
17													
18													
19													
20													
21													

THIS COMPETENCY SHEET LISTS ALL THE SKILLS REQUIRED FOR THIS BOOK. THEY ARE LISTED IN A LOGICAL ORDER ALTHOUGH THERE IS NO FIXED SEQUENCE FOR COMPLETING THE EXERCISES. EACH HEADING HAS A COLUMN TO ITS RIGHT WITH SPACES TO ALLOW GRADING AFTER YOU COMPLETE THAT EXERCI[illegible] WE HAVE TAKEN INTO ACCOUNT THAT NOT EVERY EXERCISE WILL BE COMPLETED THE FIRST YEAR. THEREFORE, WE HAVE SPOTS FOR JUNIOR, SENIOR, VOCATIONAL AND INDUSTRY. AS YOU COMPLETE A PARTICULAR COMPETENCY, (OR TASK) YOU WILL BE GRADED ACCORDING TO THE SCALE AT THE BOTTOM OF THIS SHEET. ALSO, IF THERE ARE ANY MATH OR COMMUNICATION SKILLS REQUIRED THEY CAN ALSO BE GRADED USING THE CODE N, 1, 2, OR 3. THE DATE OF COMPLETION WILL BE ENTERED UNDER THE APPROPRIATE YEAR AND COMPETENCY. YOU WILL HAVE THE OPPORTUNITY TO UPGRADE ANY ONE OF THESE SKILLS AT ANY TIME AFTER YOU FIRST COMPLETE THE TASK AND HAVE THE NEW RATING ENTERED ON THIS SHEET.

RATING SCALE

N = No opportunity to perform
1 = Completed exercise with close supervision
2 = Completed exercise with little supervision
3 = Completed exercise without supervision

M = Math
C = Communications

SCHOOL ____________________ STUDENT ____________________

INSTRUCTOR ____________________ YEAR GRAD ____________________

AUTOMOTIVE ELECTRICAL COMPETENCIES-IGNITION SYSTEMS

	COMPETENCY	JR	M	C	SR	M	C	VOC	M	C	IND	M	C
E-1	Safety												
E-2	Component Identification												
E-3	Circuit Identification												
E-4	Testing-Visual Inspection												
E-5	Testing-Battery Cable, Ignition Switch and Circuit												
E-6	Testing-Ballast Resistor and Bypass Circuit												
E-7	Testing-Distributor												
E-8	Testing-Coil												
E-9	Testing- High Tension Leads												
E-10	Testing- Cap & Rotor												
E-11	Testing- Spark Plugs												
E-12	Testing- Electronic Control Modules												
E-13	Testing-Adjustments												
14													
15													
16													
17													
18													
19													
20													
21													

RATING SCALE

N = No opportunity to perform
1 = Completed exercise with close supervision
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3 = Completed exercise without supervision

M = Math
C = Communications

Electrical Competencies- Ignition Systems

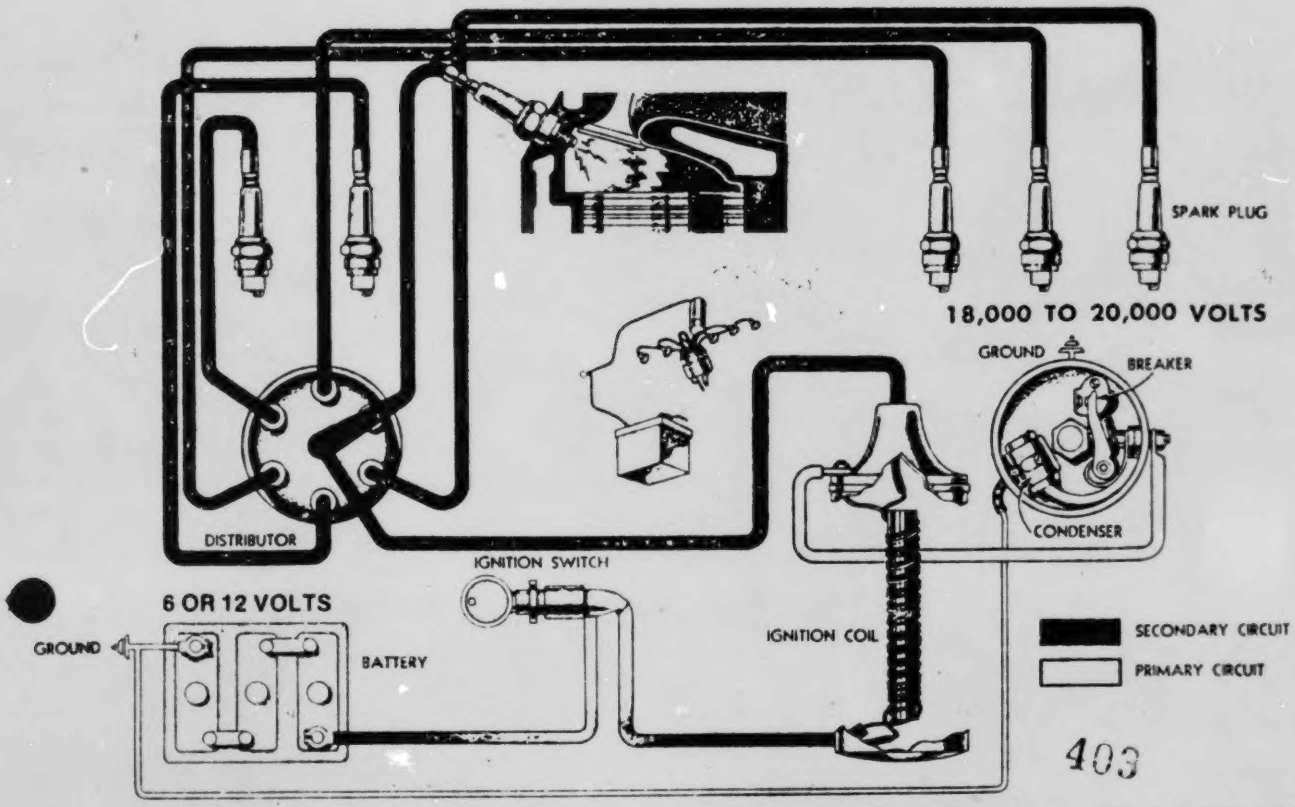
No. E- Introduction

The ignition system (Fig.1) supplies high-voltage surges to the spark plugs in the engine cylinders. These high-voltage surges must be supplied at the exact instant they are needed. That is, a surge must come along just as the piston nears TDC (top dead center) on the compression stroke. The surge then produces the spark that ignites the compressed air-fuel mixture.

The ignition system consists of a battery, switch, ignition distributor, ignition coil, wiring, and spark plugs. The distributor is two separate devices in one- a fast-acting switch and a distributing mechanism. It is driven by gearing from the camshaft of the engine. Briefly, here is how the distributor in a typical contact-point ignition system operates. The distributor shaft rotates. A cam on the upper end of the shaft, as it rotates, causes contact points to close and open. When the points are closed, the ignition coil is connected to the battery. This loads the coil with electric (electromagnetic) energy. Then, when the points are opened (as the cam continues to rotate), this energy is unloaded from the coil in the form of a high-voltage surge. The surge is directed to the proper spark plug (in cylinder ready for firing) by the distributor cap and rotor (and ignition wiring), in a manner to be explained.

In the early 1970's, automotive manufacturers swung to electronic ignition, (Fig.3). In the electronic ignition system, the contact points and condenser are replaced with a magnetic pickup device in the distributor and an electronic amplifying device using diodes and transistors.

FIG. 1



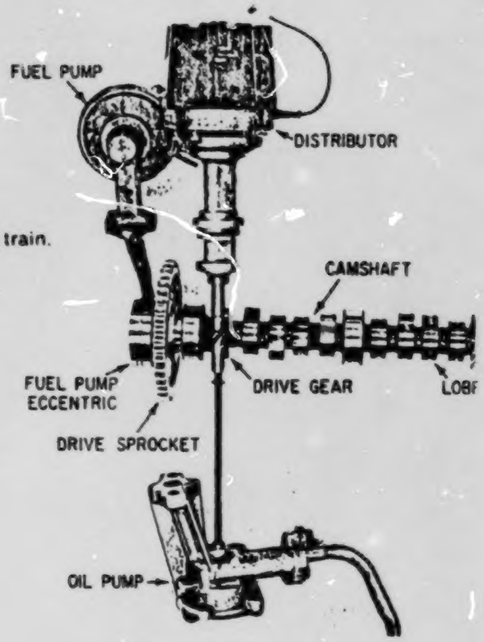

FUEL PUMP
DISTRIBUTOR
CAMSHAFT
FUEL PUMP ECCENTRIC
DRIVE GEAR
LOB
DRIVE SPROCKET
OIL PUMP

Fig. 2 Typical distributor drive train.

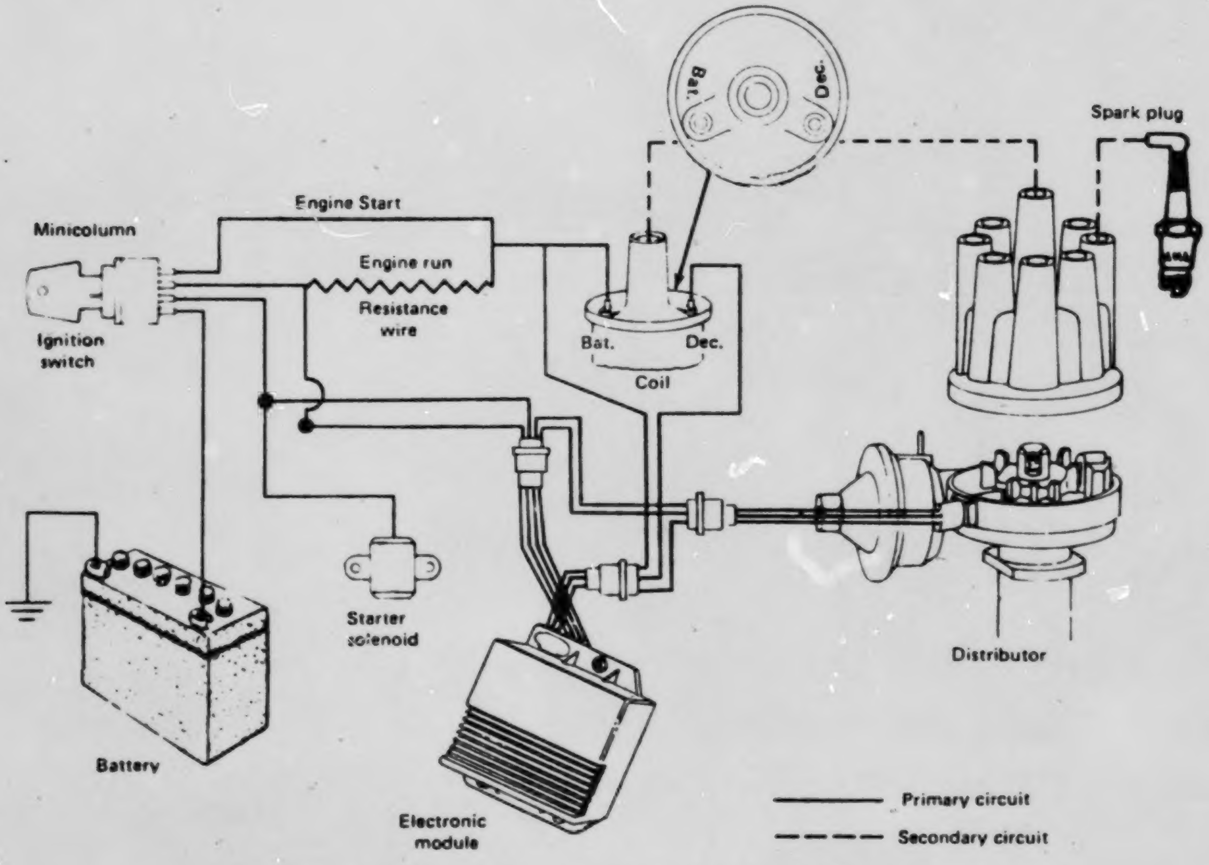

Bat.
Dec.
Spark plug
Engine Start
Minicolumn
Engine run
Resistance wire
Ignition switch
Bat.
Dec.
Coil
Distributor
Starter solenoid
Battery
Electronic module
Primary circuit
Secondary circuit

FIG. 3 Ford Solid-State (SS) ignition system. (Ford Motor Company.)

AUTO MECHANICS

Electrical Competencies- Ignition System

No. E-1 Safety

OBJECTIVE:

At the completion of this unit, the student will know and understand the safety precautions as they pertain to the ignition system. The student will pass a safety quiz with 100% accuracy.

EXPLANATION:

When performing many operations on the ignition system, it is necessary to run the engine. This brings many safety hazards into the job. It is, therefore, important that the mechanic be aware of these hazards and prevent them from becoming accidents.

MATERIALS NEEDED:

TOOLS NEEDED:

Pencil

References	Do
#1. --	#1. Read assigned references
#2. --	#2. Study Information Sheet
#3. --	#3. Complete work sheet #1
#4. p. 223-228	#4. Check with Instructor.
#5. --	
#6. p. 19-22	
#7. p. 12-16	
#8. --	

Electrical Compentencies- Ignition

No. E-1 Safety

Safety Rules

1. When it is necessary to run the engine (for adjusting dwell or timing or for diagnosis):
   - A. Make sure transmission is in park or neutral and the parking brake is on
   - B. Make sure that the exhaust system is connected to cars tailpipe
   - C. Make sure that there are no loose connections that could cause a spark
   - D. Make sure that there are no fuel leaks

2. Before starting engine, make sure :
   - A. That test equipment leads and wires will not get caught in fan or belts
   - B. That wires and leads are not touching exhaust manifold
   - C. That spark plug wires are in correct firing order to prevent a backfire
   - D. That distributor is in time to prevent a backfire
   - E. That you have a fire extinguisher (type C) handy

3. Be careful of a high voltage shock at any secondary component such as spark plus wire, coil, distributor cap or the electronic control unit.

Electrical Competencies- Ignition System

No. E-1 Safety

Worksheet #1

Name ______________________ Date ______________ Grade ____________

T F 1. Do not run an engine in a closed shop without having the exhaust vented outside of the building.

T F 2. Timing light leads cannot be damaged by the fan blades.

T F 3. Make sure that the transmission is in park of neutral and the parking brake is on while setting the ignition timing.

T F 4. Leave all electrical connections loose until the last operation before closing the hood.

T F 5. The correct firing order is not important until after the timing has been set.

T F 6. The distributor should be static timed before attempting to start the engine.

T F 7. Keep fingers and loose clothing away from the belts of a running engine.

T F 8. Any type of fire extinguisher is suitable for an electrical or fuel fire.

T F 9. A mechanic could receive a high voltage shock from a cracked distributor cap.

T F 10. Do not worry about fuel that may have leaked from the carburetor as it will evaporate when the engine warms up.

Instructor's Initials __________

AUTO MECHANICS

Electrical Competencies- Ignition System

No. E-2 Component Identification

OBJECTIVE:

After completion of this unit, the student will be able to accurately identify the components of the ignition system.

EXPLANATION:

It is essential that the mechanic be able to identify the components of the ignition system in order for him to do the necessary diagnosis and repair.

MATERIALS NEEDED:

TOOLS NEEDED:

Pencil

References	Do
#1. Ch. 21	#1. Read assigned reference
#2. Ch. 3, p. 51-72	#2. Study information sheets
#3. p. 476-543	#3. Complete worksheet #1,p. 2
#4. p. 395-426	#4. Check with Instructor. Electronic Ignition
#5. Ch. 16, p. 201-230	#5. Read assigned references.
#6. p. 296-321	#6. Study Information Sheet #2, p.1-10
#7. Ch. 22, p. 259-281	#7. Complete Worksheet #2, p.1-3
#8. --	#8. --

Electrical Competencies - Ignition System

No. E-2 Component Identification

Information Sheet # 1

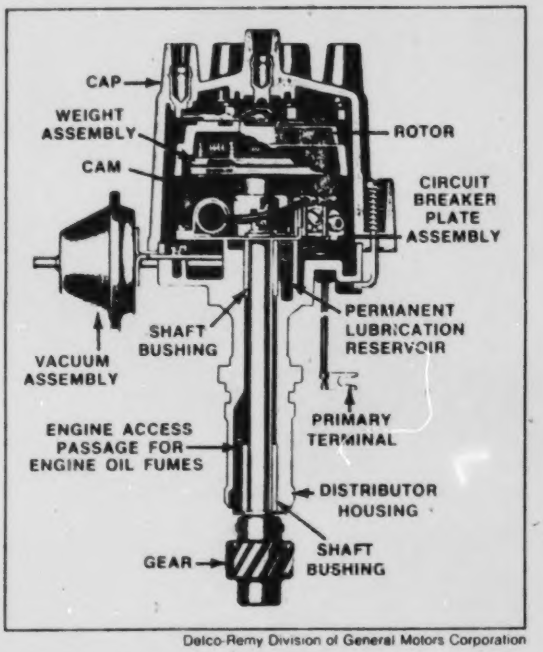
In the Introduction to this unit, figures 1-3 show the basic ignition circuit in picture form. Information sheet # 1 will break each component down to show nomemclature and then basic function of each component.

The distributor has a shaft on which a cam is mounted. The cam has the same number of high points, or lobes, as there are cylinders in the engine.

When the engine is running, the distributor shaft turns, and the cam repeatedly opens and closes the contact points. Every time a cam lobe comes up under the rubbing block on the contact arm, it pushes the arm out. This separates the movable contact point from the stationary contact point. Then, as the cam continues to move around, the cam lobe moves out from under the rubbing block. Now the spring on the movable contact point pushes it back into contact with the stationary contact point.

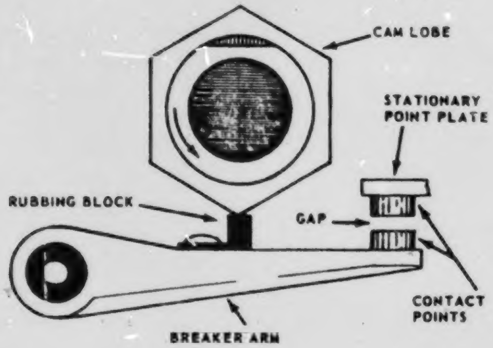
Every time the contact points close, the primary winding of the ignition coil is connected to the barrery (providing the ignition switch is turned on). This connection allows current to flow through the primary winding. A magnetic field builds up. (You remember that current flowing in a winding produces a magnetic field around the winding.) Then, when the contact points are separated, the current stops flowing and the magnetic field collapses. It is this build-up and collapse of the magnetic field that produce the high-voltage sparks.

The distributor then takes these high voltage sparks and distributes them to the correct spark plug at the correct time. The distributor has two spark advance mechanisms to correct for engine changes. There is a mechanical advance mechanism to advance the spark as engine speed increases and a vacuum advance to control the spark according to engine load.

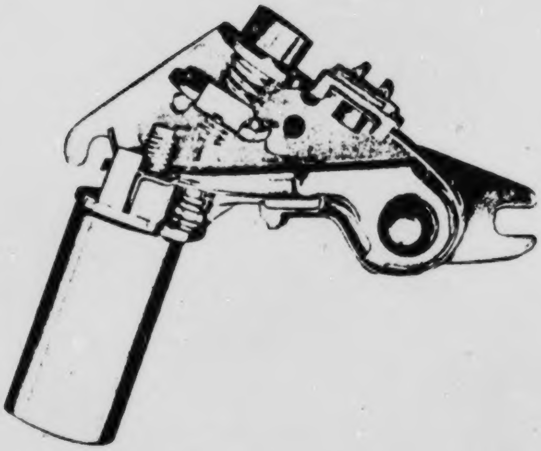

CAP
WEIGHT ASSEMBLY
ROTOR
CAM
CIRCUIT BREAKER PLATE ASSEMBLY
SHAFT BUSHING
PERMANENT LUBRICATION RESERVOIR
VACUUM ASSEMBLY
PRIMARY TERMINAL
ENGINE ACCESS PASSAGE FOR ENGINE OIL FUMES
DISTRIBUTOR HOUSING
SHAFT BUSHING
GEAR

Delco-Remy Division of General Motors Corporation

The contact points or breaker points have the task of mechanically making and breaking the primary circuit of the ignition system. This is done by having the distributor cam turn so that the cam lobe pushes the rubbing block back and the rubbing block forces the breaker arm back separating the contact points which opens the primary circuit.


CAM LOBE
STATIONARY POINT PLATE
RUBBING BLOCK
GAP
CONTACT POINTS
BREAKER ARM

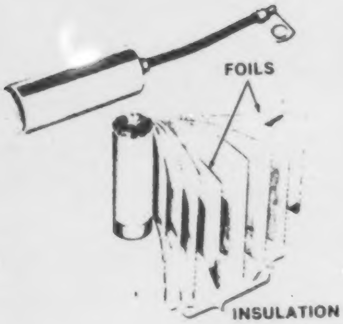
Contact Points



Contact set with attached condenser. With this set, called a *uniset* by the manufacturer, the points and condenser are replaced as a unit. (*Delco-Remy Division of General Motors Corporation*)

Condenser

The condenser is also called the capacitor. It consists of two long strips of lead or aluminum foil, with insulating strips of paper between the, wrapped in a winding. The winding is put into a metal can with a bracket so that the assembly can be mounted in the distributor. The can is connected to one of the two metal strips. The other metal strip is connected to the lead. In the distributor the can is attached to the plate on which the contact points are mounted. This plate is called the "breaker plate."



A condenser assembled and with the winding partly unwound.

The lead is connected to the movable contact arm. The condenser, therefore, is connected across the breaker points. One of the metal strips is connected to the movable contact point. The other metal strip is connected to the stationary (the grounded)contact point.

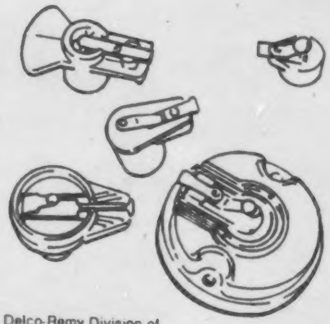
Now, let's see what the condenser does. When the contact points begin to separate, the current stops flowing. However, it "wants" to continue to flow. In other words, current tries to keep flowing even as the distributor contacts start to separate. Without the condenser, it would jump across the separating contact points, making an arc. This arc would waste most of the high-voltage surge, and there might not be enough voltage left in the coil to produce the spark at the spark plug. Also, an arc across the points would soon burn the points so that they would no longer make good contact. The condenser prevents an arc from forming. It monentarily provides a place for the current to flow while the contact points separate. In doing this, the condenser brings the current flowing in the primary winding to a quick stop. This speeds up the magnetic-field collapse and increases the voltage in the secondary winding. With a higher voltage, the high-voltage surge is more intense, and the spark at the spark plug is stronger. A strong spark assures good ignition of the compressed air-fuel mixture.

Rotor Action

Let's take a closer look at the distributing action of the distributor. On top of the cam in the distributor is a rotor. The rotor sits on the cam.

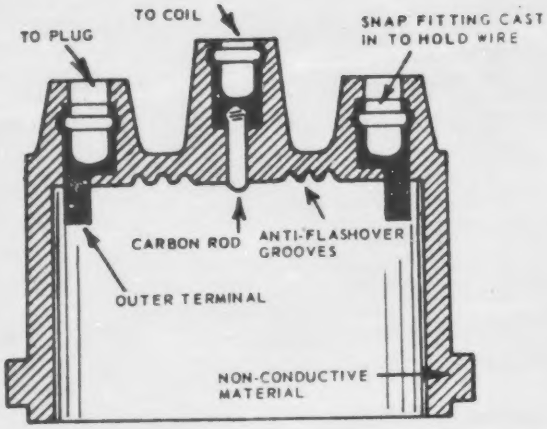
As the distributor shaft rotates, the cam and the rotor also rotate. The purpose of the rotor is to connect the center terminal of the distributor cap to the outside terminals of the distributor cap.

The terminals in the cap are insulated from one another and held in place in the cap. The center terminal of the cap has a carbon button on its lower end. This button rests on one end of the rotor blade. A small spring holds the carbon button and rotor blade in continuous contact. Therefore, the rotor blade is always connected to the secondary winding of the ignition coil. Whenever the coil secondary winding produces a high-voltage surge, the metal blade of the rotor sends the surge to the proper spark plug. In other words, the rotor has turned so that it points to the correct side terminal. That is, the rotor points to the side terminal which is connected to the spark plug in the cylinder that is ready to fire.

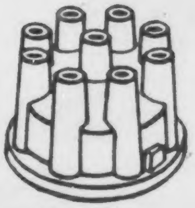


Delco-Remy Division of
General Motors Corporation

Types of distributor rotors. The one at the lower left has a carbon resistor. The one at the lower right is attached to the advance mechanism by screws.



Distributor cap – section view.



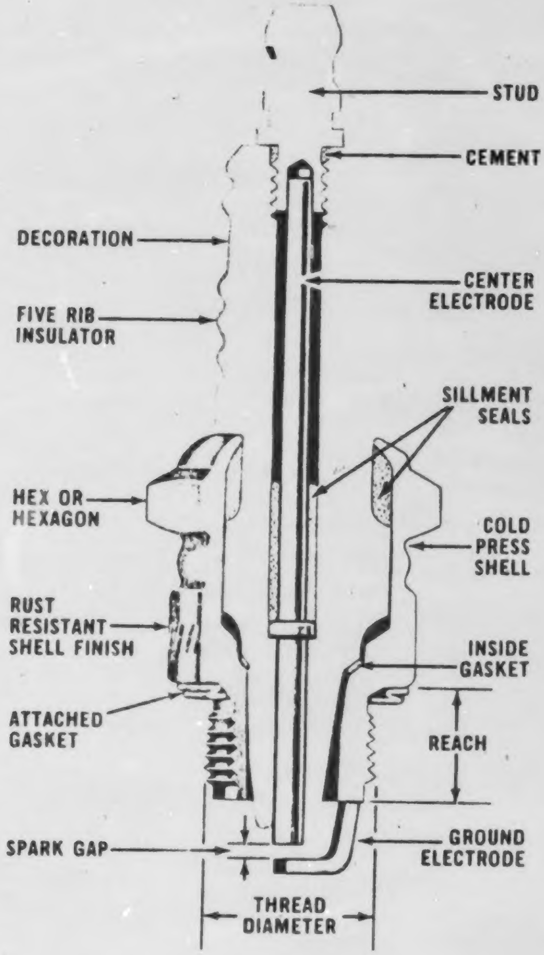
Distributor Cap

Spark Plug

The spark plug has an insulator to hold the center eleectrode, the shell to support the insulator, and the ground electrode. When the high-voltage surge enters the spark plug, it flows down the center electrode and jumps from the lower end of the center electrode to the ground electrode just beneath it.

Some spark plugs have a resistor built in. This resistor limits interference on radio and television receivers. Every high-voltage surge that flows from the coil secondary through the cables to the spark plugs sends out a form of radio wave. The radio wave is actually a magnetic field that can make noise in the radio or blur the television picture. The resistor concentrates the high-voltage surge and therefore reduces the interference.

The spark plug screws into the combustion chamber to "fire" the air/fuel mixture. It provides two electrodes with an air gap for the spark to "jump" across. When the spark jumps the electrodes, it ignites the fuel in the cylinder.


STUD
CEMENT
DECORATION
CENTER ELECTRODE
FIVE RIB INSULATOR
SILLMENT SEALS
HEX OR HEXAGON
COLD PRESS SHELL
RUST RESISTANT SHELL FINISH
INSIDE GASKET
ATTACHED GASKET
REACH
SPARK GAP
GROUND ELECTRODE
THREAD DIAMETER

Spark plug nomenclature

Coil Construction

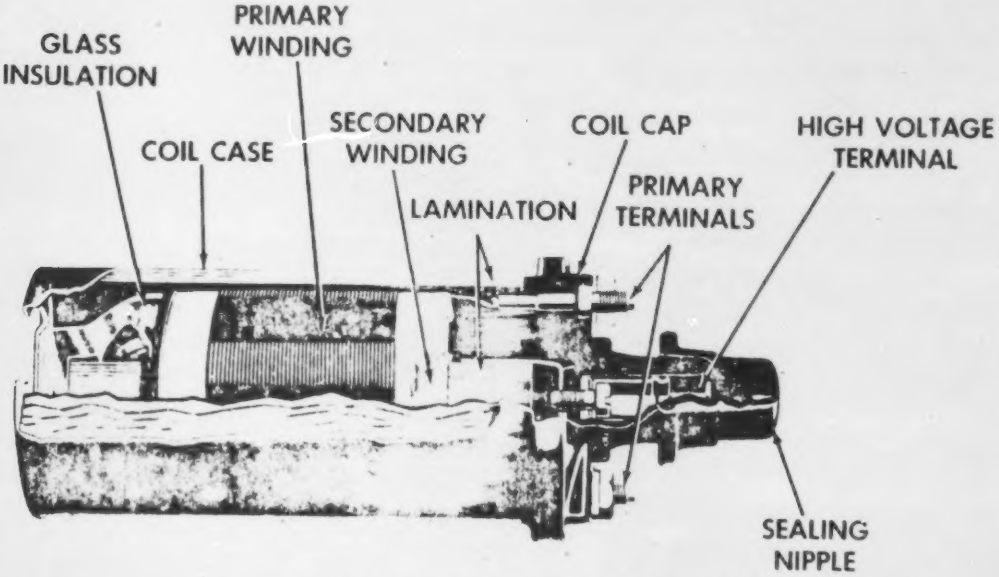
The coil is constructed with a special laminated iron core. Around this central core, many thousands of turns of very fine copper cire are wound. This fine wire is insulated by a thin coating of special insulation material. One end of the fine wire is connected to the primary circuit wire within the coil. All these turns of fine wire form what is called the SECONDARY circuit coil windings.

Several hundred turns of heavier copper wire are wrapped around the secondary coil windings. Each end is connected to a primary circuit terminal on the coil. These windings are also insulated. The turns of heavier wire form the PRIMARY circuit coil windings.

The core, with both the SECONDARY and PRIMARY windings attached, is placed inside a laminated iron shell. The job of the shell is to help concentrate the magnetic lines of force that will be developed by the windings.

This entire unit is then placed inside a steel, aluminum or Bakelite case. In some coil designs, the case is filled with a special oil. It is then hermetically sealed to prevent the entrance of dirt or moisture. Electrical outlets, such as the primary terminals, are generally contained in the coil cap. They are carefully sealed because the coil must withstand vibration, heat, moisture and the stresses of high induced voltages.

Coils vary in size and shape to meet the varying demands of different types of installations.



Ignition coil nomenclature (Delco-Remy Division, General Motors Corporation).

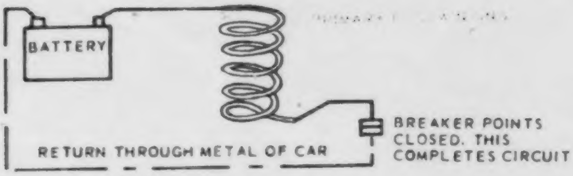
Coil

The primary circuit leads from the resistor to the coil.

An ignition coil is actually a pulse-type transformer that raises the battery voltage up to, and exceeding 20,000V.

How a Coil Works

When the ignition switch is turned on, the current flows through the primary windings of the coil, to the ground and back to the battery via the frame. As the current passes through the primary winding, a strong magnetic field is formed around both the primary and secondary windings. When the points open, this magnetic field collapses. The collapse of the magnetic field induces a high (up to 20,000) voltage in the secondary winding which leaves the coil high tension terminal and goes to the distributor cap.


BATTERY
BREAKER POINTS CLOSED. THIS COMPLETES CIRCUIT
RETURN THROUGH METAL OF CAR

Primary current flows through primary coil winding when points are closed.

Resistor

Electricity flows from the ignition switch to the resistor. From the resistor, the current travels to the coil.

The resistor controls the amount of current reaching the coil. The resistor may be either the simple or the ballast type.

There are resistors designed for specific jobs. One type, used on Ford V-8 engines for many years, was a simple unit used to reduce battery voltage reaching the coil. The primary circuit passed through the resistor, cutting down the voltage to a predetermined level. The type of coil utilized in these installations would overheat if the battery voltage reached the coil without being reduced.

This type of simple resistor was not temperature sensitive. It would deliver about the same voltage to the coil regardless of whether or not the coil had reached operating temperature. Fig. 3-4.

A modern adaptation of the resistor is used in high-compression, high horsepower engines. This type is known as the BALLAST resistor. It is a temperature sensitive, variable resistance unit.

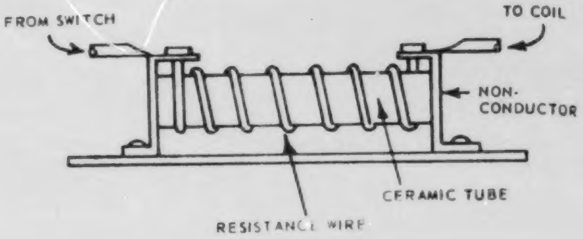


Fig. 3-4. Simple resistor in primary circuit of ignition system.

A ballast resistor is designed to reduce the voltage available to the coil at low engine speeds, and to increase the voltage at the higher rpm range when it is needed. Without the resistor, the coil would require enough voltage to function efficiently at high speeds. Such voltage would cause excessive heating at low speeds. It would also cause oxidization of the contact points (a blue scale-like deposit).

The ballast type resistor tends to heat up at low engine speeds as the duration of flow in the primary circuit is longer, and with less interruption by the contact point opening. As it heats up, its resistance value goes up, causing lower voltage to pass the coil.

As engine speed increases, the points open and close more rapidly and the duration of current flow lessens. This causes a lowering of temperature. As the temperature drops, the resistor allows the voltage to the coil to increase. As high speeds, the coil received most all the battery voltage.

High engine speeds shorten the coil saturation period. (The saturation period is the length of time the points are closed and current is flowing through the primary windings of the coil.) It is obvious that this condition would require full voltage.

The ballast resistor is constructed of a special type wire, the properties of which tend to increase or decrease the voltage in direct proportion to the heat of the wire.

Electrical Competencies - Ignition System

No. E-2 Component Identification

Information Sheet # 2

Information sheets numbered # 2 of this unit will deal with electronic ignition systems. Because of the variations in design, this unit will deal with the systems by manufacturer.

Delco-Remy

Introduction

Delco-Remy has introduced two basic ignition systems which cover all General Motors cars equipped with High Energy Ignition. The main features of the V8 and V6 HEI system are shown in figures 1 and 2. The basic difference in the two systems is the separate coil used on the 4 and 6 cylinder in-line engines as shown in figure 3.

A magnetic pickup assembly located over the shaft contains a permanent magnet, a pole piece with internal teeth, and a pickup coil. When the teeth of the timer core rotating inside the pole piece line up and separate with the teeth of the pole piece, an induced voltage in the pickup coil signals the all-electronic module to open the ignition coil primary circuit. The primary current decreases and a high voltage is induced in the ignition coil secondary winding, which is directed through the rotor and high voltage leads to fire the spark plugs. The capacitor suppresses radio noise (Fig. 4).

The magnetic pickup assembly is mounted over the main bearing on the distributor housing, and is made to rotate by the vacuum control unit, this providing vacuum advance. The timer core is made to rotate about the shaft by conventional advace weights, thus providing centrifugal advance.

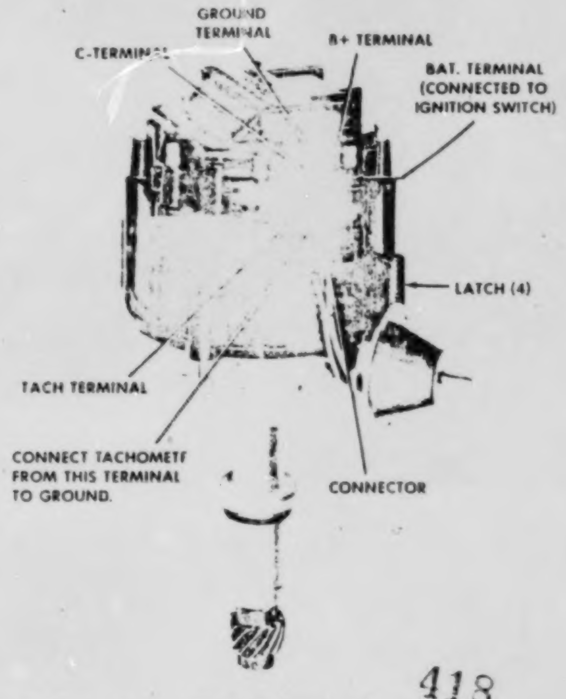

GROUND TERMINAL
C-TERMINAL
B+ TERMINAL
BAT. TERMINAL (CONNECTED TO IGNITION SWITCH)
LATCH (4)
TACH TERMINAL
CONNECT TACHOMETER FROM THIS TERMINAL TO GROUND.
CONNECTOR

Figure 1 — Typical V8 High Energy Ignition distributor.

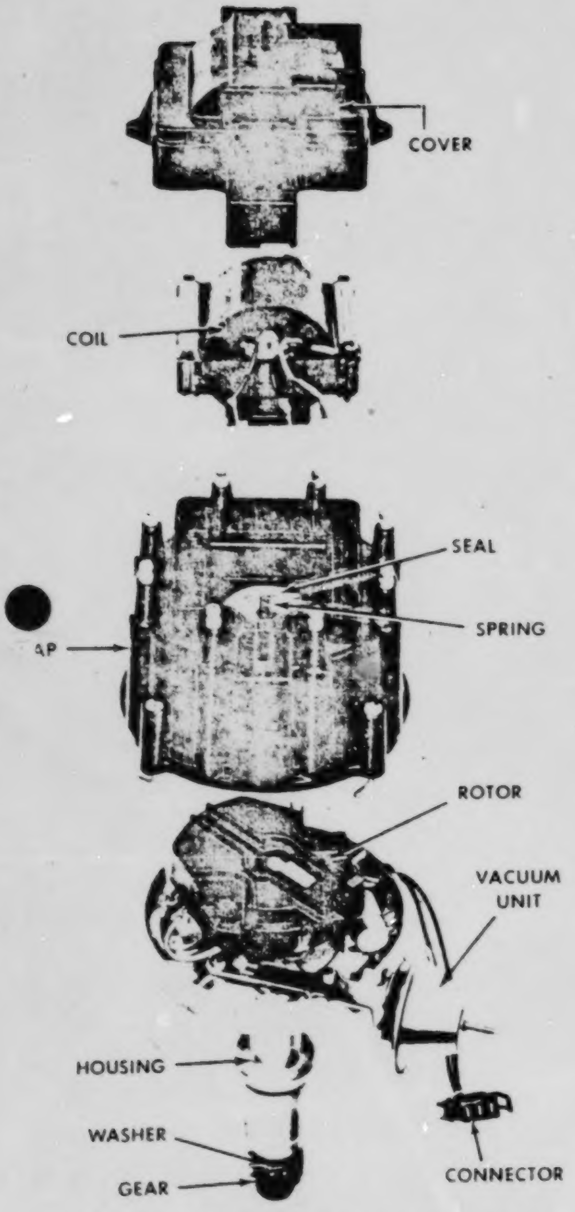

COVER
COIL
SEAL
SPRING
AP
ROTOR
VACUUM UNIT
HOUSING
WASHER
GEAR
CONNECTOR

Figure 2 — Partially exploded view of V8 system

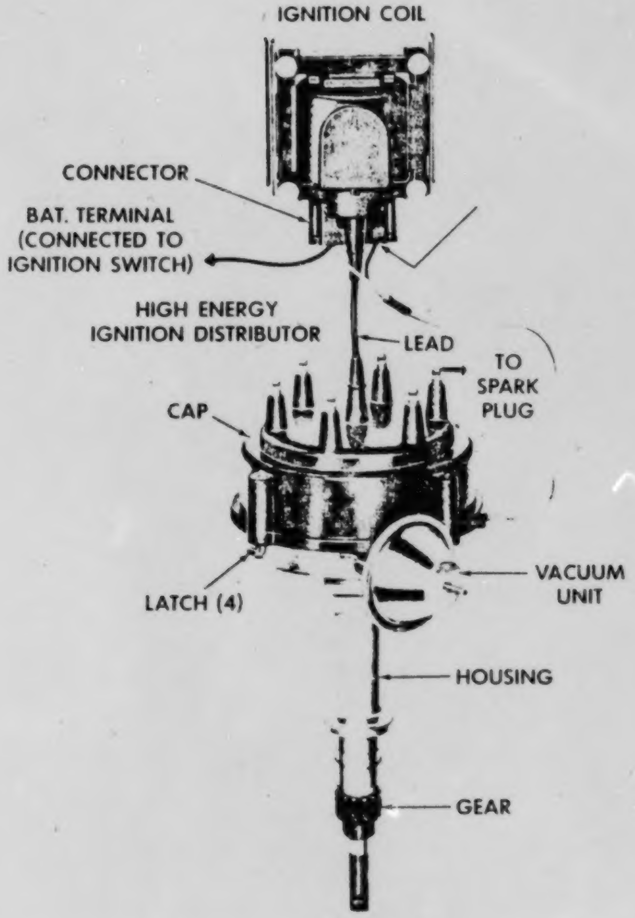

IGNITION COIL
CONNECTOR
BAT. TERMINAL (CONNECTED TO IGNITION SWITCH)
HIGH ENERGY IGNITION DISTRIBUTOR
LEAD
TO SPARK PLUG
CAP
LATCH (4)
VACUUM UNIT
HOUSING
GEAR

Figure 3 — Typical 6 cyl. in-line HEI system. 4 cyl. is same except cap has towers for plugs, and timer core has 4 teeth.

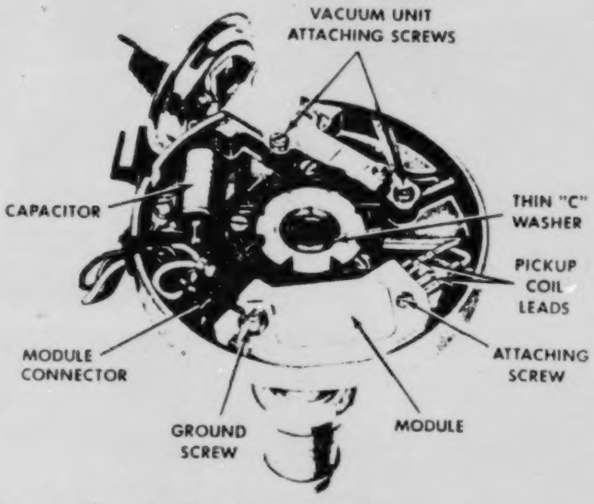

VACUUM UNIT ATTACHING SCREWS
CAPACITOR
THIN "C" WASHER
PICKUP COIL LEADS
ATTACHING SCREW
MODULE CONNECTOR
GROUND SCREW
MODULE

Figure 4 — Unit with shaft assembly removed.

Chrysler Electronic Ignition

The Electronic Ignition System consists of the Battery, Ignition Switch, Dual Ballast Resistor, Control Unit Coil, Distributor, Spark Plugs and all their Wiring, Insulators and Connectors.

The primary circuit consists of the battery, ignition switch, compensating (0.5 ohm) side of the ballast resistor, primary windings of the ignition coil, power switching transistor of the control unit, and the vehicle frame.

The secondary circuit consists of the coil secondary windings, distributor cap and rotor, spark plug wires, spark plugs, and vehicle frame.

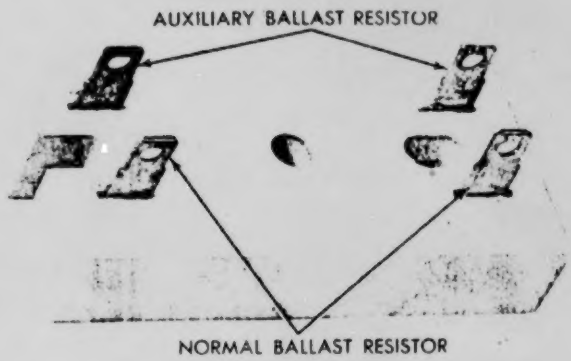
The compensating resistance maintains constant primary current with variation in engine speed. During starting this resistance is by-passed, applying full battery voltage to the ignition coil.

In addition to the two basic circuits there are three other circuits. They are the pick up coil circuit, control unit feed circuit, and auxiliary ballast circuit.

Two circuits are used to operate the circuitry of the control unit. These are the auxiliary ballast circuit which uses the 5 ohm section of the dual ballast resistor and the control unit feed circuit.

The pick up circuit is used to sense the proper timing for the control unit switching transistor.

The reluctor rotating with the dirstributor shaft produces a voltage pluse in the magnetic pickup each time a spark plug should be fired. This pulse is transmitted through the pickup coil to the power switching transistor in the control unit and causes the transistor to interrupt the current flow through the primary circuit. This break in the primary circuit induces a high voltage in the secondary coil circuit and fires a spark plug.

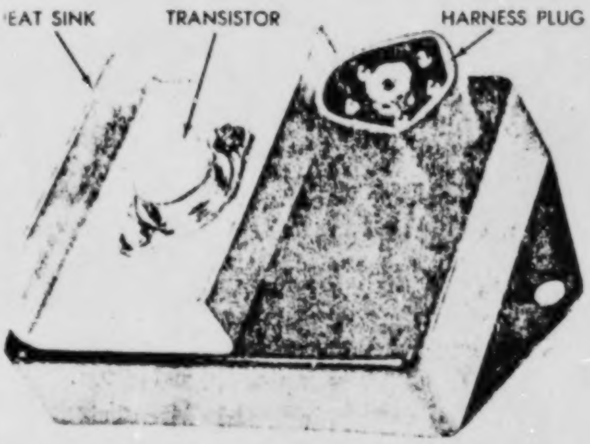


-Dual Ballast Resistor

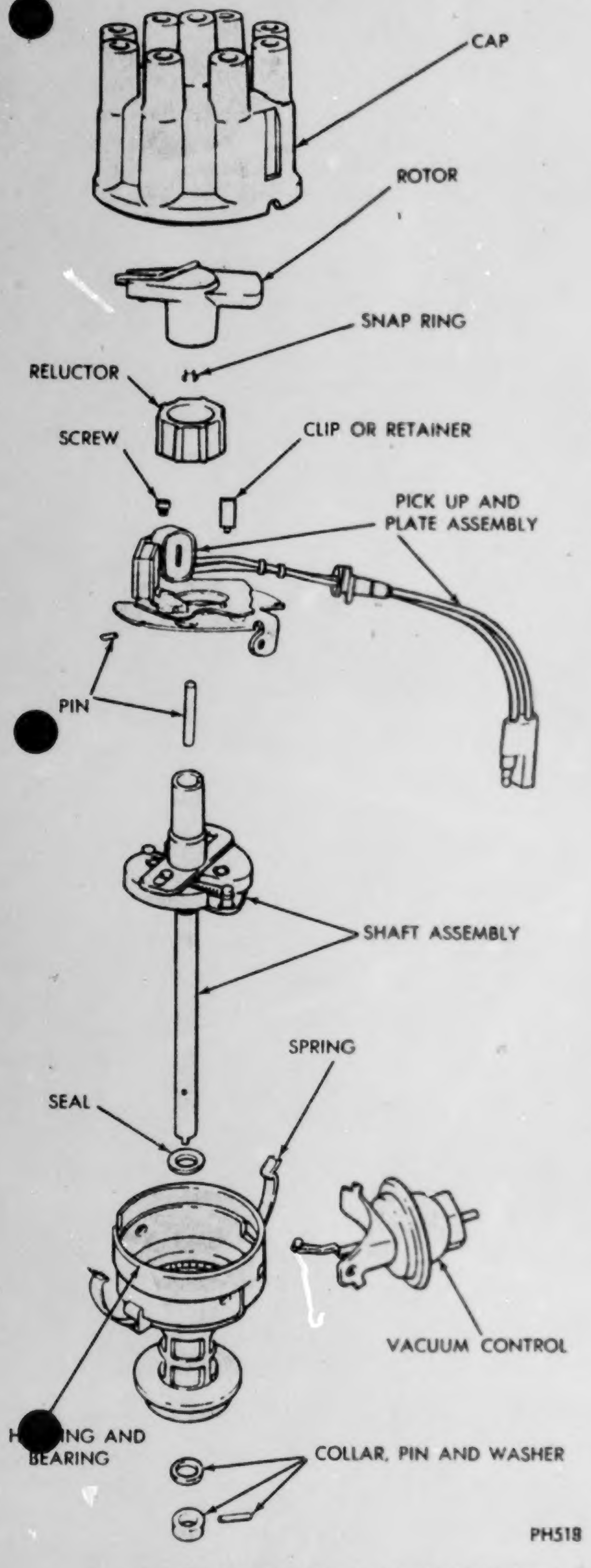
Electrical Competencies - Ignition System

No. E-2 Component Identification

Information Sheet # 2
Page 4


EAT SINK
TRANSISTOR
HARNESS PLUG

Electronic Control Unit


CAP
ROTOR
SNAP RING
RELUCTOR
SCREW
CLIP OR RETAINER
PICK UP AND
PLATE ASSEMBLY
PIN
SHAFT ASSEMBLY
SPRING
SEAL
VACUUM CONTROL
H[illegible]ING AND
BEARING
COLLAR, PIN AND WASHER
PH518

–8 Cylinder Distributor (Exploded View)

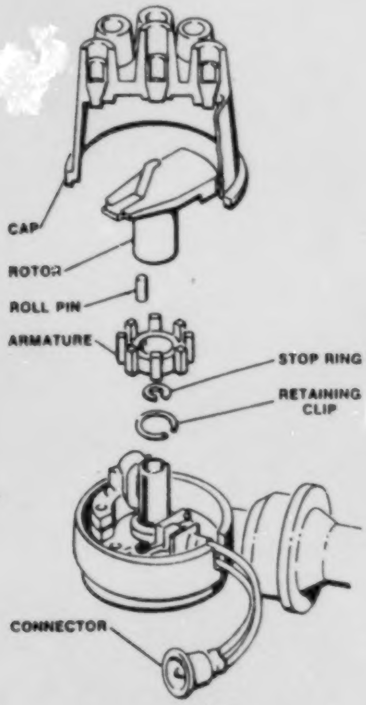
Ford Breakerless Solid-State Ignition

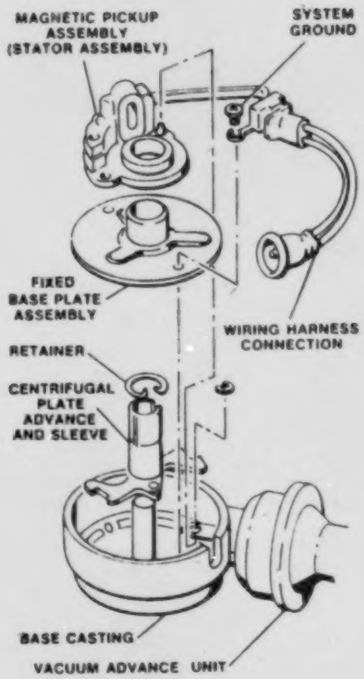
The Ford breakerless ignition was introduced in mid-1973, was available on all V-8 and inline 6-cylinder engines in 1974, and became standard on all engines in 1975 and later models.

It consists of a magnetic pulse distributor, an electronic control module, and a special coil. The distributor uses a conventional cap, rotor, and body. Inside the distributor, the points and condenser have been replaced by a magnetic pickup assembly. A gear-like armature mounted on the distributor shaft takes the place of the cam. Distributor shaft rotation causes the armature poles to pass the core of the magnetic pickup assembly and induce a voltage in the pickup coil. This signals the electronic control module to open the primary ignition circuit, thus inducing secondary voltage in the coil. Secondary voltage is then distributed to the plugs through the rotor, cap, and cables.

The electronic control module is a solid-state assembly that switches the primary circuit in place of conventional breaker points. The coil used with the Ford breakerless ignition is a special oil-filled type that is identified by a blue case or tower. The coil primary terminals are labelled BAT and DEC (Distributor Electronic Control).

The magnetic pickup inside the distributor consists of a permanent magnet inside a small coil. It is mounted on a movable plate that is connected to a vacuum advance unit. The movabel plate rides on a fixed baseplate assembly. Conventional centrifugal advance weights are also used.


CAP
ROTOR
ROLL PIN
ARMATURE
STOP RING
RETAINING CLIP
CONNECTOR


MAGNETIC PICKUP ASSEMBLY (STATOR ASSEMBLY)
SYSTEM GROUND
FIXED BASE PLATE ASSEMBLY
WIRING HARNESS CONNECTION
RETAINER
CENTRIFUGAL PLATE ADVANCE AND SLEEVE
BASE CASTING
VACUUM ADVANCE UNIT

The Ford solid-state ignition system uses a standard primary circuit ballast resistor wire.

Since its introduction in late 1973, the Ford solid-state ignition has undergone several circuit design changes. These changes center around the wire color coding and connector identification of the seven wires that feed out of the control module. The seven wires feed out of the module in two groups, one ending in a three-terminal connector and the other in a four-terminal connector. Both connectors plug into the main vehicle wiring harness.

The wire color coding is the key to tracing the ignition circuit on cars of different years. Power from the ignition switch reaches the module through the white wire while the engine is cranking but through the red wire once it is running. Distributor signals are received through the orange and purple wires. Primary current from the coil is carried by the green wire to the module. The black wire is a ground connection between the module and the distributor. The blue wire protects the system against transcient voltages.

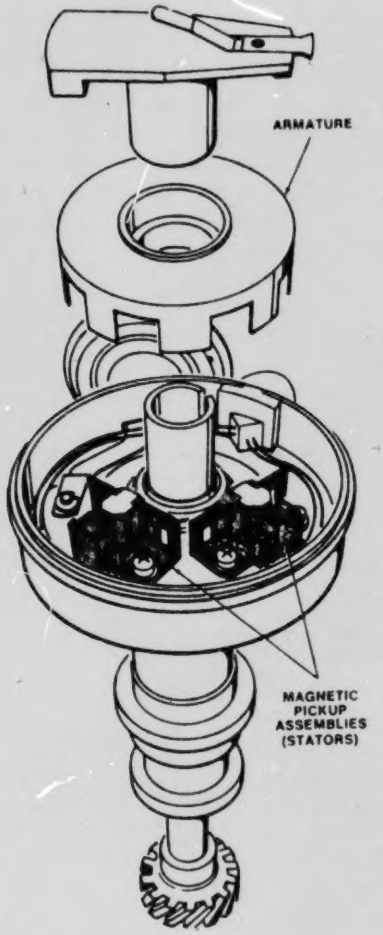
Wire color coding and connector arrangements are the same for 1973 and 1974 systems. In 1975 systems, the color coding is unchanged, but the wire arrangement at the connectors and the connector shapes were altered. In 1976, the blue wire for system protection was eleminated and the module circuitry was redesigned to dump temporary voltage surges. The connector shapes and terminal arrangements were also changed in 1976. Because of these wiring changes, modules and wiring harnesses are not interchangeable between model years.

Computer-Controlled Timing

Ford Motor Company introduced its computer-controlled timing (CCT) system in 1976 on Continental Mark IV models. The CCT system is a development of Ford's breakerless solid-state ignition. It provides electronically controlled spark timing that is said to improve fuel economy and driveability while maintaining exhaust emissions at the required low levels.

The CCT system uses a distributor with a redesigned armature and two pickup assemblies. The two pickups are offset from each other in relation to cylinder firing position. One is used for initial timing, the other for advance. Switching between the two pickups is controlled by the spark timing control module, which is a computer module used along with the basic ignition control module of the Ford system.

The spark timing module receives signals from sensors that monitor engine speed, transmission gear, manifold vacuum, and coolant temperature. The timing module processes the sensor information and sends timing advance or retard signals to the ignition control module. The electronically controlled timing supplements the conventional centrifugal and vacuum advance mechanisms of the distributor.



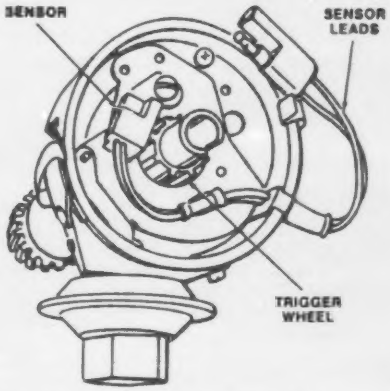
Prestolite Breakerless Inductive Discharge Ignition System- IHC & AMC

The Prestolite breakerless inductive discharge ignition is an electronic ignition system first used on some 1974 V-8 engines from International Harvester. In 1975, this system was continued on 4- and 8-cylinder IHC engines, and a variation was introduced as standard equipment on 6- and 8-cylinder AMC engines.

The Prestolite system consists of a conventional ignition coil, an electronic control unit, and a breaderless distributor. Standard spark plugs and cables are used.

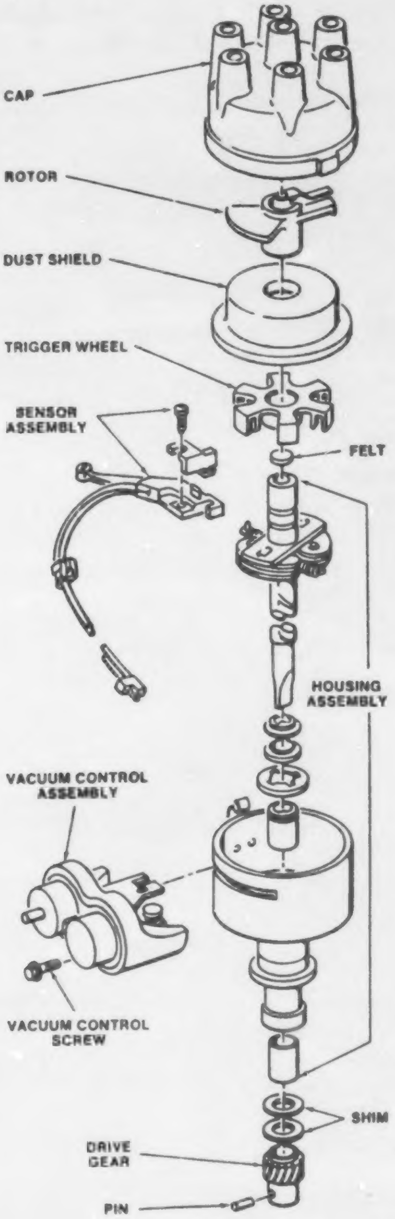
The control unit is a solid-state module and provides protection against reverse polarity and transient voltages. Because the control unit has built-in current regulation, no ballast resistor is used in the primary circuit. The circuit design allows full battery voltage to the coil whenever the ignition switch is in the ON or the START positions.

The breakerless distributor uses a conventional cap and a rotor and conventional centrifugal and vacuum advance mechanisms to control timing. A sensor and trigger wheel provide the signal to the control unit to interrupt primary current flow. When the ignition is on, an oscillator in the control unit excites the sensor in the distributor and develops an electromagnetic field. As the leading edge of a tooth on the rotating trigger wheel enters the sensor field, the tooth reduces the strength of the oscillation in the sensor. When the oscillator strength is reduced to a given level, a demodulator circuit in the control unit switches a power transistor that is in series with the coil primary circuit. The transistor interrupts the primary current, which causes a normal inductive discharge in the coil secondary. Although the AMC and International systems are similar in operating principles and circuit designs, the mechanical components, such as the sensor and trigger wheel, are different.



The trigger wheel in the IHC distributor is similar to Chrysler's reluctor or Ford's armature. The trigger wheel has four or eight external teeth, depending on the number of engine cylinders. The sensor is located alongside the rotating wheel. As in the Chrysler system, the air gap between the trigger wheel and the sensor can be adjusted.

The dwell angle on the Prestolite-Internation ignition is affected by the distributor air gap. The dwell decreases as the sensor is moved closer to the trigger wheel and increases as the sensor is moved away. Dwell changes approximately one-half degree for each .001 inch of sensor movement. Dwell and air gap specifications vary for different years and engine models.

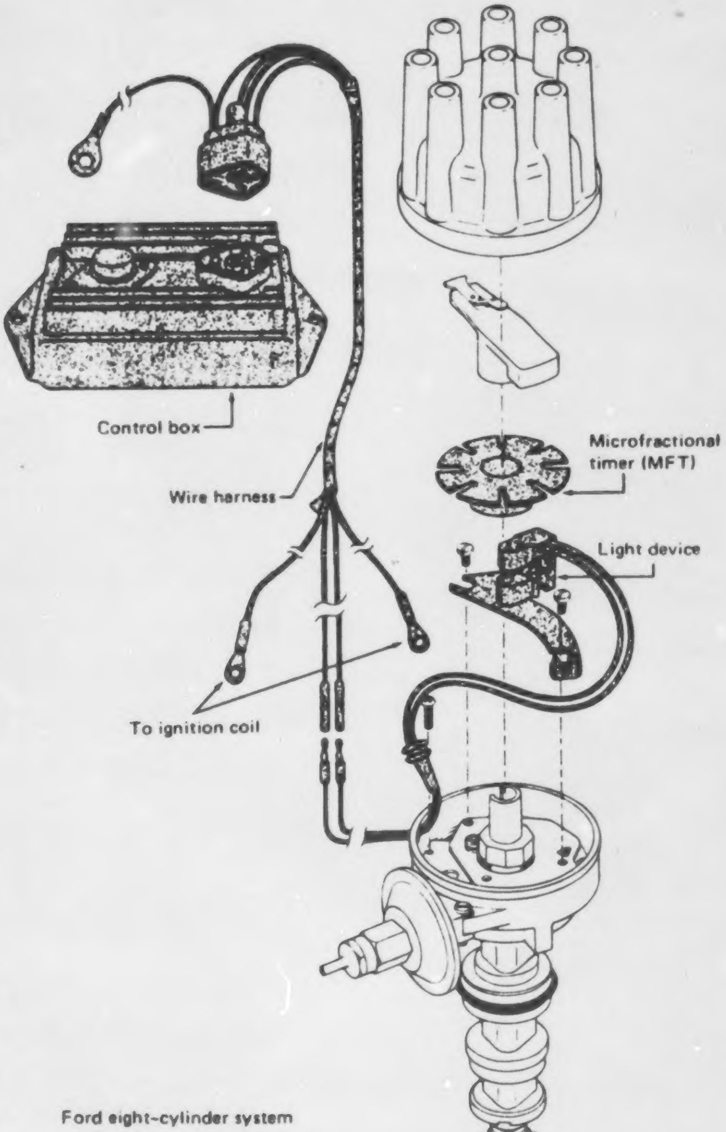

CAP
ROTOR
DUST SHIELD
TRIGGER WHEEL
SENSOR ASSEMBLY
FELT
HOUSING ASSEMBLY
VACUUM CONTROL ASSEMBLY
VACUUM CONTROL SCREW
SHIM
DRIVE GEAR
PIN

The sensor and trigger wheel in the AMC distributor are different from those in the IHC distributor. The sensor is pin shaped, and trigger wheel teeth are shaped like an inverted U. The teeth pass over the sensor, and air gap is not adjustable as in the IHC unit. Dwell is not adjustable and is determined by the control unit and the angle between the trigger wheel teeth.

Light - Emitting Diode

The photoelectric cell type uses a small incandescent ligh focused on a photoelectric cell and interruped by a shutter rotated in place of the conventional distributor cam to trigger the transistor in control unit.

The light-emitting diode type is a modification of the photoelectric cell type. It uses an infrared light-emitting diode instead of an incandescent bulb, and a phote-transistor receiver, also interruped by a shutter which triggers the transistor in the control unit. This system retains the breakerless feature of the magnetic pulse and the photoelectric cell types.



Light-emitting diode type of electronic ignition system.

Ford eight-cylinder system

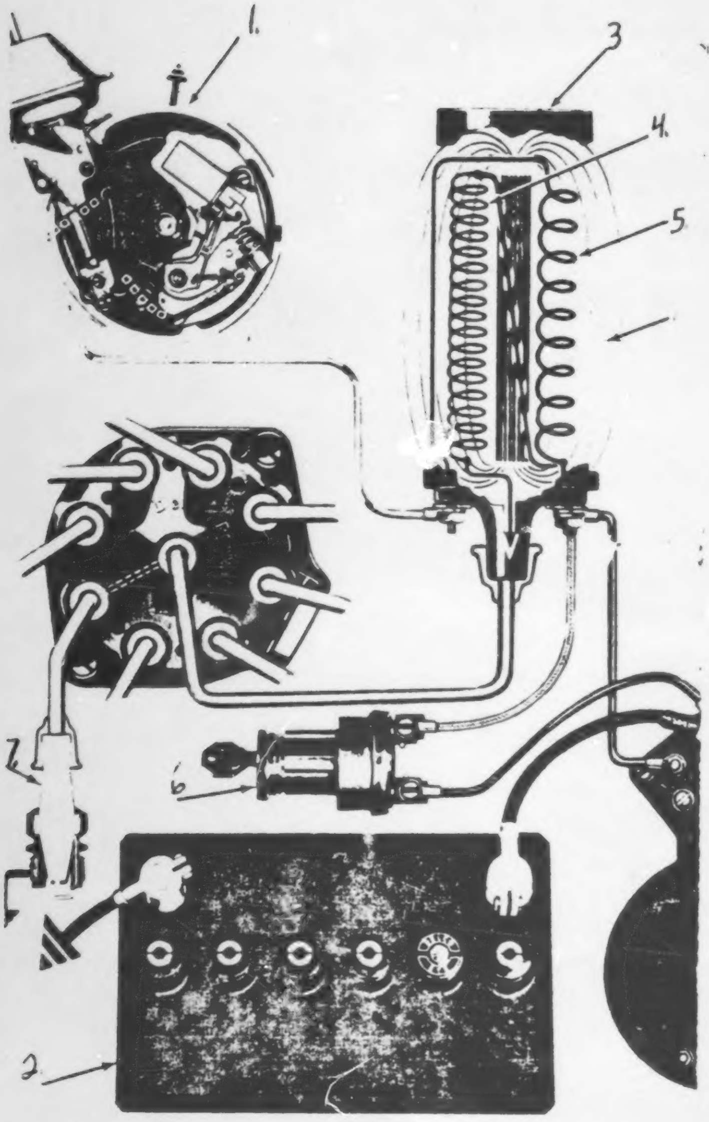
Electrical Competencies- Ignition System

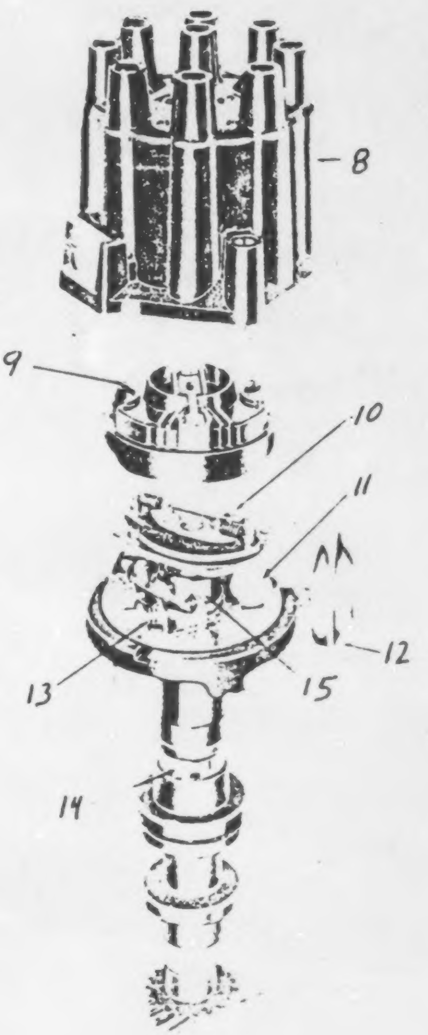
No. E-2 Component Identification

Worksheet #1

Name ______________________ Date ____________ Grade __________

Identify the Following Components




8
9
10
11
12
13
15
14

Electrical Competencies- Ignition System

No. E-2 Component Identification

Worksheet #1
Page 2

Name ____________________ Date __________ Grade __________

MATCHING: Match the name of the component in Column A with the component found on page 1 of this worksheet. Place the number of the component from Column A in the correct space in Column B.

Column A	Column B
1. Ignition Switch	1. ______________
2. Distributor Cap	2. ______________
3. Name Tag and Number	3. ______________
4. Distributor	4. ______________
5. Distributor Cam	5. ______________
6. Battery	6. ______________
7. Coil	7. ______________
8. Contact Points	8. ______________
9. Primary Winding	9. ______________
10. Rotor	10. ______________
11. Secondary Winding	11. ______________
12. Condenser	12. ______________
13. Vacuum Advance	13. ______________
14. Spark Plug	14. ______________
15. Mechanical Advance	15. ______________

Instructor's Initials __________

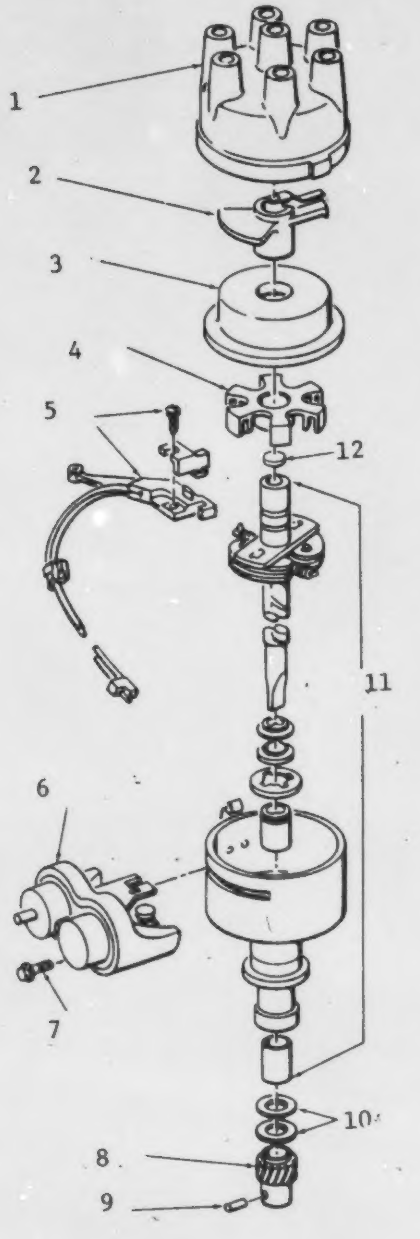
Electrical Competencies - Ignition System

No. E-2 Component Identification

Worksheet # 2

Name ______________________________ Date __________ Grade ______________

Prestolite



Identify Components

1. ______________________

2. ______________________

3. ______________________

4. ______________________

5. ______________________

6. ______________________

7. ______________________

8. ______________________

9. ______________________

10. ______________________

11. ______________________

12. ______________________

Instructor's Initials ____________

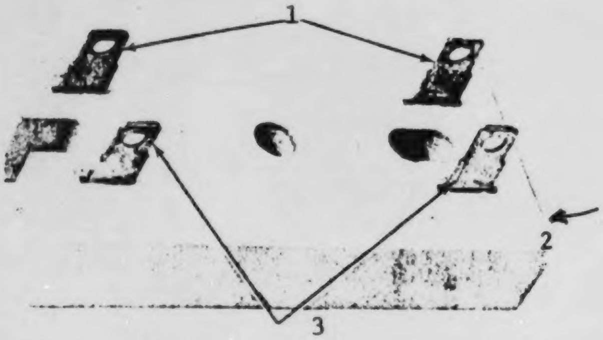
Electrical Competencies - Ignition System

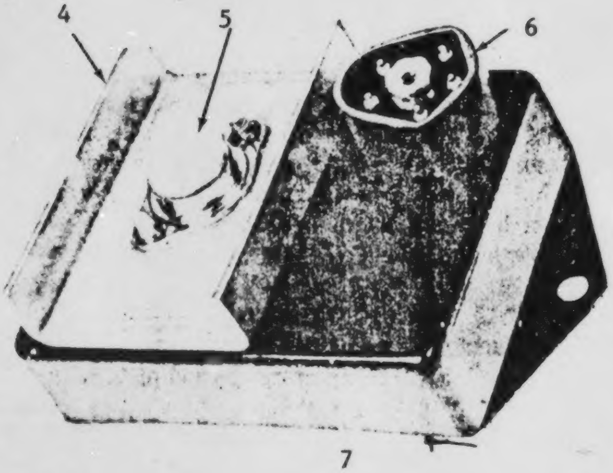
No. E-2 Component Identification

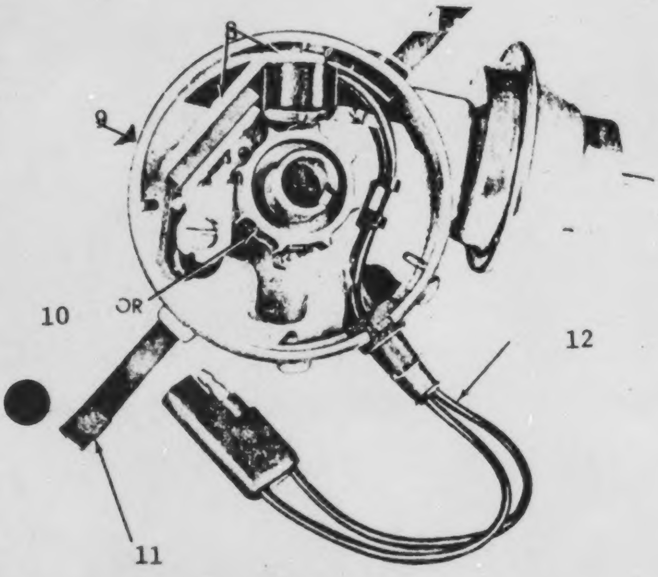
Worksheet # 2
Page 2

Name ______________________________ Date ______________ Grade ____________

Chryslyer Electronic Ignition







Identify Components

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________
11. ______________________________
12. ______________________________

Instructor's Initials ____________

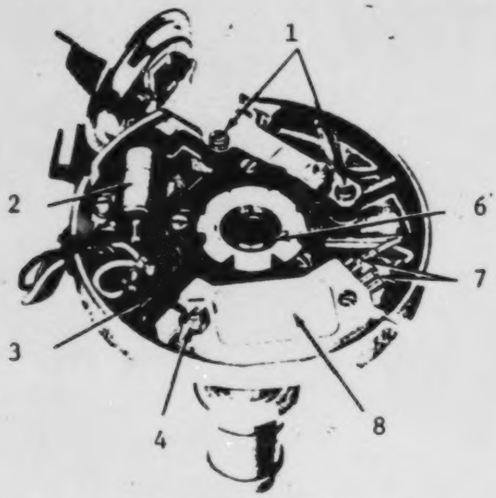
Electrical Competencies - Ignition System

No. E-2 Component Identification

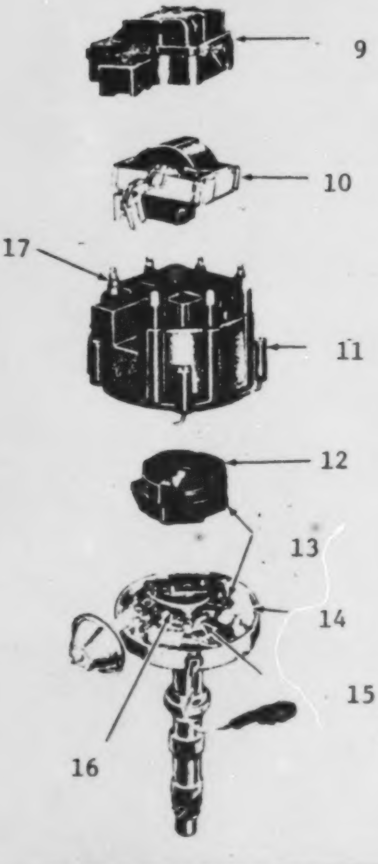
Information Sheet # 2
Page 3

Name ______________________ Date __________ Grade __________

General Motor's High Energy Ignition



5 —Unit with shaft assembly removed.


9
10
17
11
12
13
14
15
16

Identify

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________
11. ______________________________
12. ______________________________
13. ______________________________
14. ______________________________
15. ______________________________
16. ______________________________
17. ______________________________

AUTO MECHANICS

Electrical Competencies - Ignition System

No. E-3 Primary and Secondary Circuit Identification

OBJECTIVE: At the completion of this unit the student will know and understand the flow of electricity through the primary and secondary ignition circuit.

EXPLANATION: Proper understanding of ignition current flow will make diagnostic problems easier and quicker to solve.

MATERIALS NEEDED:

TOOLS NEEDED: pencil

References	Do
#1. Ch 21	1. Read assigned references
#2. p. 51-72	2. Complete worksheets 1, 2, & 3.
#3. p.476-543	3. Have instructor check.
#4. p. 395-426	
#5. p. 201-230	
#6. p. 296-321	
#7. p. 259-281	
#8. --	

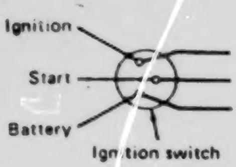
Electrical Competencies - Ignition System

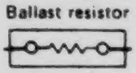
No. E-3 Ignition Circuit Identification

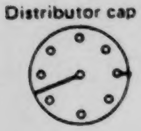
Worksheet # 1

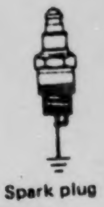
Name ____ Date ______________ Grade __________

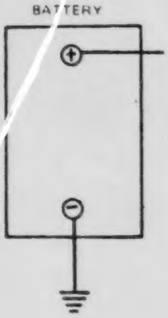
DIRECTIONS: With a pencil connect the following ignition components together using one line for primary and two parallel lines for secondary.

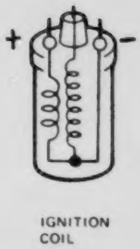

Ignition
Start
Battery
Ignition switch

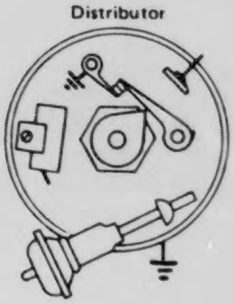

Ballast resistor


Distributor cap






+
-
IGNITION
COIL


Distributor

Identify an auto manufacturer using this system ____________________________.

Instructor's Initials __________________

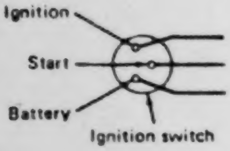
Electrical Competenices - Ignition System

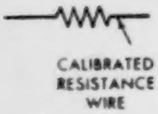
No. E-3 Ignition Circuit Identification

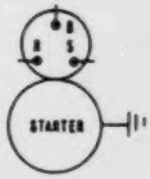
Worksheet # 2

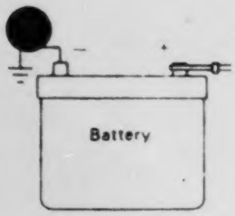
Name ____ Date __________ Grade __________

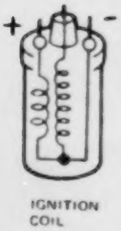
DIRECTIONS: With a pencil connect the following ignition and starter related components together using one line for starter/primary and two parallel lines for secondary.

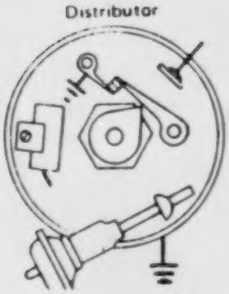

Ignition
Start
Battery
Ignition switch

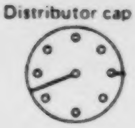

CALIBRATED RESISTANCE WIRE

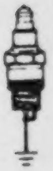





+
-
IGNITION COIL


Distributor


Distributor cap



Identify an auto manufacturer using this system ______________________.

Instructor's Initials ______________

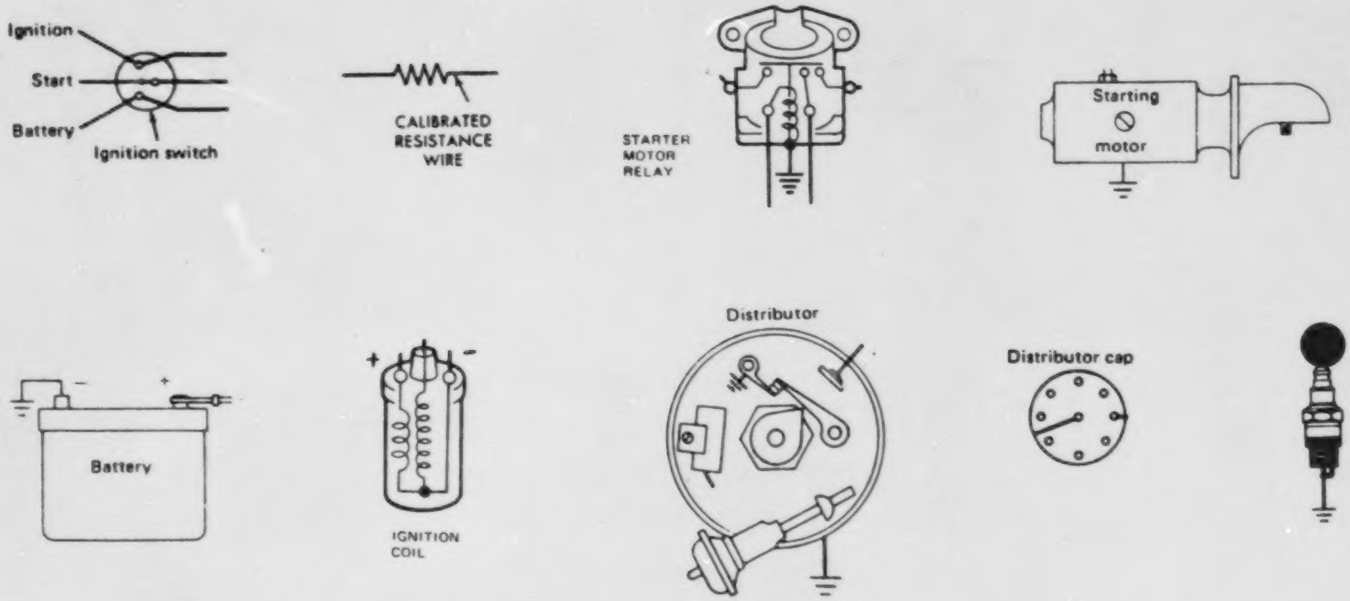
Electrical Competencies - Ignition System

No. E-3 Ignition Circuit Identification

Worksheet # 3

Name ______________________________ Date __________ Grade __________

DIRECTIONS: With a pencil connect the following ignition and starter related components together using one line for starter/ primary and two parallel lines for secondary.


Ignition
Start
Battery
Ignition switch
CALIBRATED RESISTANCE WIRE
STARTER MOTOR RELAY
Starting motor
Battery
+
−
IGNITION COIL
Distributor
Distributor cap

Identify an auto manufacturer using this system ____________________.

Instructor's Initials ____________________

AUTO MECHANICS

Electrical Competencies -Ignition Systems

No. E-4 Visual Inspection

OBJECTIVE:

After completing this unit, the student will be able to visually inspect an ignition system.

EXPLANATION:

Many of the malfunctions may be spotted by merely looking at the system.

MATERIALS NEEDED:

TOOLS NEEDED:

Pencil

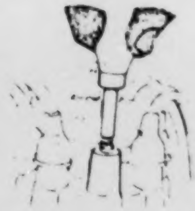
References	Do
#1. Ch. 21	#1. Read assigned references
#2. Ch. 3	#2. Study information sheet
#3. p. 473-543	#3. Do a visual inspection of an ignition system completing worksheet.
#4. p. 395-426	
#5. p. 201-227	
#6. p. 310-321	
#7. p. 259-281	

Electrical Competencies - Ignition System

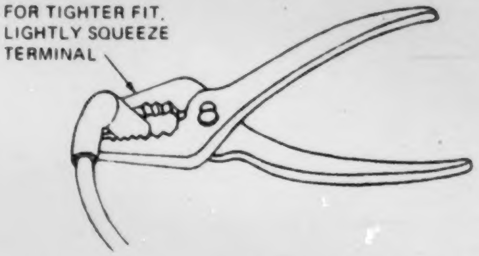
No. E-4 Testing - Visual Inspection

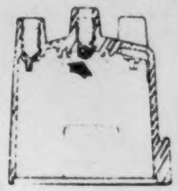
Information Sheet # 1

Many times an ignition problem can be identified by merely making a visual inpection without the use of sophisticated test equipment. The first step of the visual inspection would be to check to see that all wires are in place and that the connections are good and tight. Often an ignition miss is caused by a loose spark plug wire that is not making a good connection. The cure for this would be to replace the wire on the spark plug or distributor cap. Other quick visual checks would be: primary wirer and connection, coil cracked or leaking, distributor loose, distributor cap cracked or carbon tracked, broken or badly burned rotor, points that are badly burned or pitted, cracked insulator on a spark plug. Many times a cracked insulator will not show up on a visual check, however, a very audible snapping sound will occur when the engine is running.

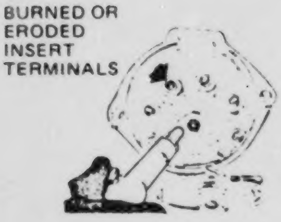


CLEANING TOWER INSERT

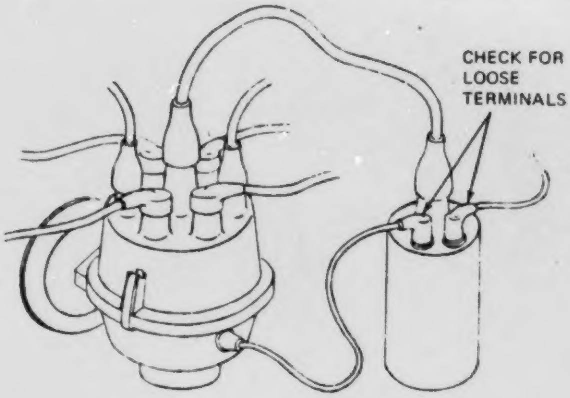

FOR TIGHTER FIT, LIGHTLY SQUEEZE TERMINAL

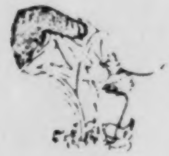


INSPECTION OF CARBON ROTOR BUTTON

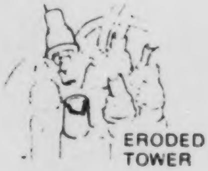

BURNED OR ERODED INSERT TERMINALS

BLOWING OUT INSIDE OF DISTRIBUTOR CAP AND INSPECTION OF INSERT TERMINALS

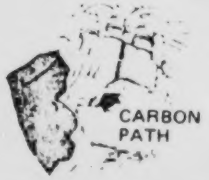

CHECK FOR LOOSE TERMINALS



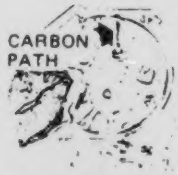
CLEANING IGNITION COIL


ERODED TOWER

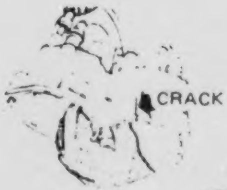
INSPECTION OF DISTRIBUTOR-CAP TOWERS


CARBON PATH

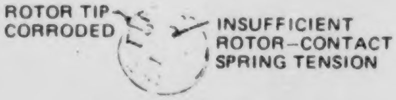
CLEANING AND INSPECTION OF OUTSIDE OF DISTRIBUTOR CAP


CARBON PATH

CLEANING AND INSPECTION OF INSIDE OF DISTRIBUTOR CAP



REPLACING DISTRIBUTOR CAP


ROTOR TIP CORRODED
INSUFFICIENT ROTOR-CONTACT SPRING TENSION

ROTOR INSPECTION

Electrical Competencies- Ignition Systems

No. E-4 Testing- Visual Inspection

Worksheet #1

Name ______________________ Date ____________ Grade ____________

Visual Inspection

Check for loose wires or connections at:

	OK	NOT OK
1. spark plugs	____	____
2. Coil primary	____	____
3. Coil Output	____	____
4. Coil High Tension	____	____
5. Distributor Cap	____	____
6. Points	____	____

Check for spark arcing at:

	OK	NOT OK
1. Coil	____	____
2. Spark Plugs	____	____
3. Spark Plug Wires	____	____
4. Distributor Cap	____	____

Check Components:

1. Coil: Cracked ________ Dirty ________ Oil Leakage ________
2. Distributor Cap: Cracked ________ Carbon Tracked ________
3. Rotor: Burned ________ Broken ________
4. Spark Plugs: Cracked ________ Oily ________ Broken ________
5. Distributor: Loose ________
6. Contact Points: Burned or Pitted ________ Worn Rubbing Block ________

Instructor's Initials ________

X

AUTO MECHANICS

Electrical Competencies- Ignition Systems

No. E-5 Testing Battery, Cables, Ignition Switch and Circuit

OBJECTIVE:

After completing this unit, the student will be able to test the battery, cable, ignition switch and circuit.

EXPLANATION:

This unit covers the testing of the ignition switch and its circuit.

MATERIALS NEEDED:

TOOLS NEEDED:

Voltmeter

References	Do
#1. Ch. 21	#1. Read reference.
#2. Ch. 3	#2. Study Worksheet.
#3. p. 473-543	#3. Test ignition switch and circuit completing worksheet.
#4. p. 395- 426	
#5. p. 201-227	
#6. p. 310-321	
#7. p. 259-281	
#8. --	

Electrical Competencies - Ignition System

No. E-5 Testing - Battery, Cables, Ignition Switch and Circuit

Information Sheet # 1

Battery and Cables

A weak or no spark condition may occur from a defective battery or cable. Usually this will happen when the engine is being cranked. This condition will cause a cranking voltage that is too low to produce a good spark from the coil. An indication of this problem is a very slow cranking speed. Refer to the unit on Batteries for information on testing and correcting a battery problem.

Ignition Switch and Circuit

Ignition Switch

The primary circuit starts at the battery and flows through an insulated wire to the ignition switch. The usual ignition switch utilizes a key to operate it. It connects or disconnects the flow of electricity across the terminals. The ignition switch may have additional terminals that supply electricity to other units on the car when the key is turned on.

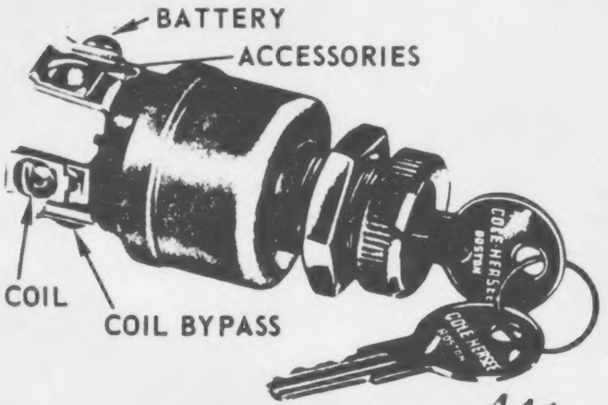
The coil bypass terminal furnishes current directly to coil (without passing through ballast resistor) during engine cranking.

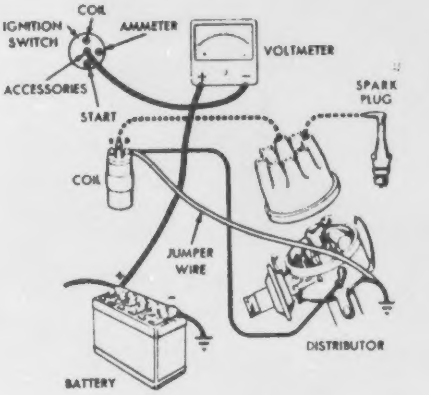
Occasionally an ignition switch will fail in service and must be replaced. If the switch is suspected of being faulty, it may be checked by connecting a voltmeter as shown. Connect a jumper wire from the distributor terminal of the coil to ground. Switch should be ON, accessories and lights OFF.

If the reading is 0.3 volt or less, the ignition switch and the relay-to-switch wire are all right. A reading in excess of 0.3 volt indicates either the wire or switch (or both) are defective.

Jiggle the ignition key in and out. The voltmeter reading should remain constant. Turn the key off and on. The meter reading should return to the same level each time. Flex switch wire at both ends. The meter reading should remain steady.

When replacing an ignition switch, mark wires for correct replacement. DISCONNECT BATTERY GROUND CABEL TO PREVENT ACCIDENTAL SHORTS.





Checking ignition switch with voltmeter. (Ford)

Electrical Competencies - Ignition System

No. E-5 Testing - Battery, Cables, Ignition Switch and Circuit

Worksheet # 1

Name ______________________________ Date __________ Grade __________

Ignition Switch and Circuit

Procedure:

1. Connect jumper wire from distributor terminal of coil to ground.
2. Connect voltmeter (0-16Volt scale) with positive lead to battery positive terminal and negative lead to accessory terminal on ignition switch (see diagram on information sheet # 2).
3. Read voltage ____________________
4. Turn switch on: Voltage ______________

   Is voltage difference greater than .3 volts ______________
5. Turn switch on and off several times noting voltmeter readiness.

   Is there ever a change greater than .3 volts __________________?
6. Wiggle key in switch watching voltmeter

   Is there ever a change greater than .3 volts? __________________
7. Condition of ignition switch and circuit ________________________

   ____

   ____

   ____

AUTO MECHANICS

Electrical Competencies-Ignition Systems

No. E-6 Testing Ballast Resistor and Bypass Circuit

OBJECTIVE:

After completing this unit, the student will be able to test an ignition resistor or bypass circuit.

EXPLANATION:

Both of these components or circuits can be tested with the same meter and the same connection, therefore we will test both at the same time.

MATERIALS NEEDED:

TOOLS NEEDED:

Voltmeter
Ohmmeter

References	Do
#1. Ch. 21	1. Read assigned reference.
#2. --	2. Study information sheet
#3. p. 473-543	3. Test a ballast resistor and bypass circuit completing worksheet #1
#4. p. 395-426	
#5. p. 201-227	4. Check with instructor
#6. p. 310-321	
#7. p. 259-280	
#8. --	

Electrical Competencies - Ignition System

No. E-6 Testing Ballast Resistor and Bypass Circuit

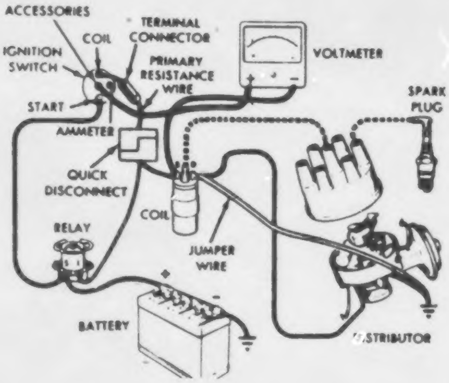
Information Sheet #1

Ignition Resistor

As you have read in the Component Identification Unit of the competency, the ballast resistor or resistance wire is connected between the ignition switch and the coil primary. Its function is to reduce current and voltage at the points to lengthen point life. Usually when the resistor fails, the engine will run as long as the ignition switch is in the "start" position but as soon as the switch is released to the "on", the engine will stop. The two methods of testing this resistor, (with a voltmeter and with an ohmmeter) are explained in the next paragraph.

The ignition resistor (resistance wire or ballast type) must offer a specifiec amount of resistance to the battery to coil circuit.

One method of checking the wire type resistor is illustrated in Fig. 1. Connect the voltmeter as shown. Connect jumper wire. Turn ignition switch ON, accessories and lights OFF. Meter reading should not exceed 6.6 volts. If reading exceeds 6.6 volts, replace resistance wire. Be careful to install a correct service replacement. Recheck after replacement wire is installed.


ACCESSORIES
TERMINAL CONNECTOR
COIL
IGNITION SWITCH
PRIMARY RESISTANCE WIRE
VOLTMETER
START
SPARK PLUG
AMMETER
QUICK DISCONNECT
COIL
RELAY
JUMPER WIRE
BATTERY
DISTRIBUTOR

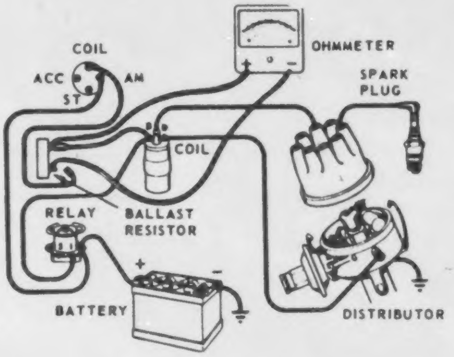

COIL
ACC
AM
ST
OHMMETER
SPARK PLUG
COIL
RELAY
BALLAST RESISTOR
BATTERY
DISTRIBUTOR

Fig. Testing ballast resistor with ohmmeter.

An ohmmeter (measures resistance in ohms) is being used to check the resistance impared by the ballast resistor in Fig. 2. DISCONNECT THE RESISTOR TO SWITCH WIRE TO PREVENT DAMAGE TO THE OHMMETER. Check reading against manufacturer's specifications. The ohmmeter can be used to check the resistance wire type also.

Do not make a test hookup that will connect the resistor directly across the battery as this will destroy the resistor.

Bypass System

On 12-volt ignition systems of recent design, there is a means of providing a higher coil input voltage for engine cranking. This takes the form of a wire with one end attached to the coil input primary terminal and the other end connected to either the starting-motor solenoid or the ignition switch, depending upon the design of the system.

Figure 1 shows the bypass system with the voltmeter position for the three tests. The bypass system works as follows: When the solenoid is energized for starting, a circuit is created directly from the insulated side of the starter circuit through the bypass wire to the input of the coil. This bypasses the ballast resistor, increasing the coil input voltage and approximately doubling the amperage.

This extra boost in ignition is required in the high-compression engines of today for ease of starting. A faulty bypass system is reflected by hard starting, especially in cold weather.

The ignition switch type of bypass system, as shown in Fig. , functions to increase coil voltage the same as the solenoid-type bypass system. Figure 2 shows the back of the ignition switch having two pertinent terminals, ignition (IGN) terminal 1 and ignition terminal 2. Ignition terminal 1 connects the switch with the coil through the nichrome-wire resistor. On the external-resistor type this terminal would feed the resistor. The secret is ignition terminal 2, which connects the bypass wire to the input of the coil. This wire is fed through a special set of contacts within the ignition switch parallel to the contact made for the solenoid. Dotted lines show the contacts. When this occurs, the resistor is bypassed and the coil receives the same boost as that described in the solenoid bypass system.

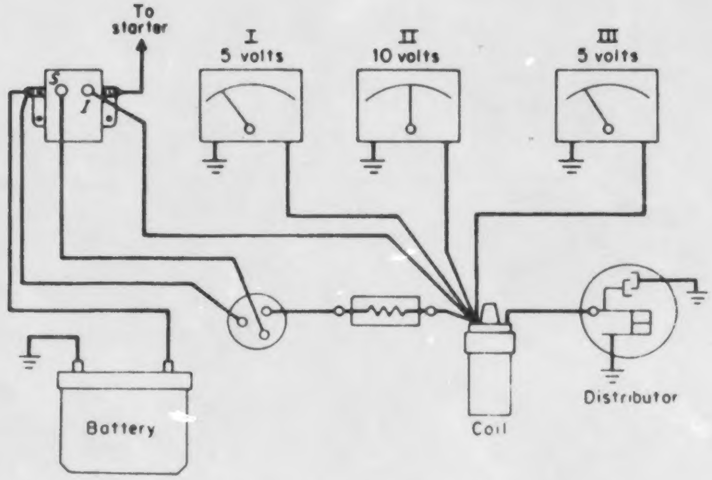


FIGURE 1 Solenoid bypass system with the voltmeter in position for the three bypass-system test readings.

Both systems are tested in the same way. A voltmeter is connected from the coil input to ground with the ignition switch on and distributor points closed; the voltmeter will read about 5 volts. Next, the engine is cranked without starting it; the voltmeter reading should jump to about 9 volts. If the voltage does not increase as described, there is a fault in the bypass system in one of the following places: the solenoid in that type, the ignition switch in that type, or the bypass wire. If the first reading is more than 5 volts, there is a possibility that the bypass contacts area stuck closed or the ballast resistor is short circuited. Check both before proceeding.

The third check with the voltmeter is taken when you stop cranking the engine. With the ignition switch on and the distributor points closed, the reading should return to the original 5 volts. Again, if the return voltage remains high, the bypass contacts are "hung up" or the resistor is short circuited.

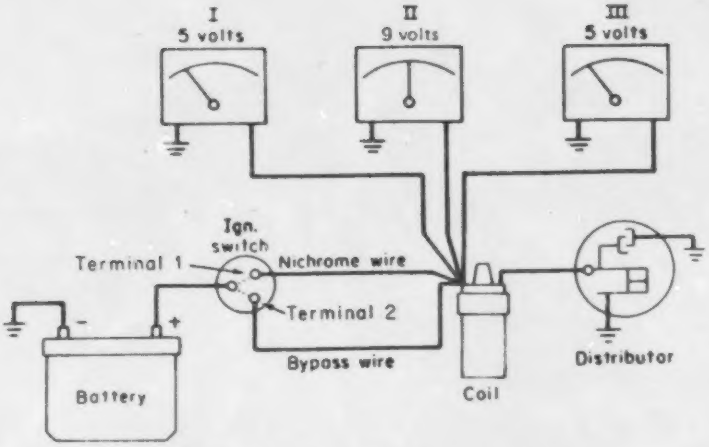


FIGURE 2 Ignition-switch-type bypass system with the voltmeter in position for the three bypass-system test readings.

Electrical Competencies - Ignition System

No. E-6 Testing Ballast Resistor and Bypass Circuit

Worksheet # 1

Name______________________________ Date__________ Grade__________

TESTING IGNITION RESISTOR AND BYPASS CIRCUIT

1. Connect voltmeter with positive lead to battery terminal of coil and negative lead to ground. Connect jumper wire from distributor terminal of coil to ground.

2. Specifications

   Voltage with ignition switch on ____________________

   Voltage during cranking ____________________

3. Voltage reading:

   Ignition switch on ____________________

   Engine cranking ____________________

   After cranking engine ____________________

4. Results ____

____

____

____

Instructor's Initials __________

AUTO MECHANICS

Electrical Competencies- Ignition System

No. E-7 Testing- Distributor

OBJECTIVE:

After completing this competency, the student will be able to test and overhaul a distributor.

EXPLANATION:

Many times a distributor or some of its parts need to be overhauled or replaced. This would be determined by testing the distributor completely.

MATERIALS NEEDED:

TOOLS NEEDED:

Hammer, Punch, Reamer, Bushing Driver, Drill, Dial Indicator, Condenser Tester, Distributor Tester, Vacuum Pump, Timing Light

References	Do
#1. Ch. 21	#1. Read references.
#2. --	#2. Study Worksheets.
#3. p. 473-543	#3. Test Distributor in a Distributor Tester completing worksheet #1.
#4. p. 395-426	#4. Overhaul a distributor completing worksheet #2.
#5. p. 201-225	
#6. p. 310-320	
#7. p. 259-280	
#8. --	

Electrical Competencies - Ignition System

No. E- 7 Testing - Distributor

Information Sheet #

Mechanical

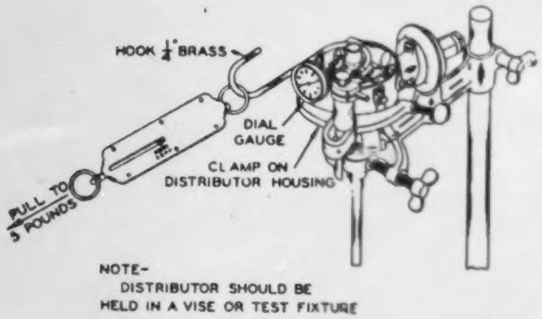
Although most of the tests in the ignition system are electrical some mechanical tests and operations to be performed on the distributor. Many distributor have bearings, housings, shafts and breaker plates that wear and must be tested and serviced.

DISTRIBUTOR OVERHAUL

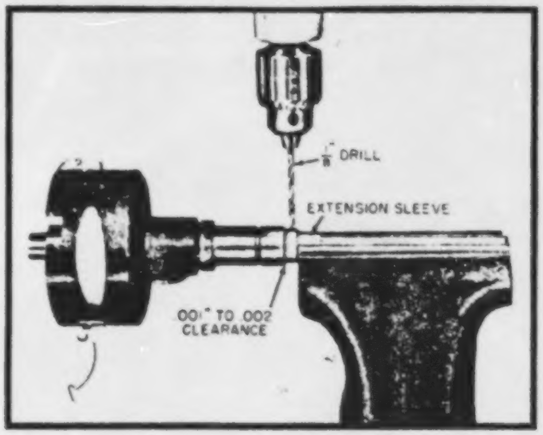
Prestolite, Chrysler, Delco-Remy

The following procedure describes the general procedure when servicing a Prestolite, Chrysler and Delco-Remy distributor wherein the breaker points are adjusted internally.

The extent to which a distributor should be disassembled will depend upon the condition of the interior and the parts to be replaced. If the distributor is clean and only parts on or above the breaker plate are to be replaced, wipe away any dirt with a clean cloth.

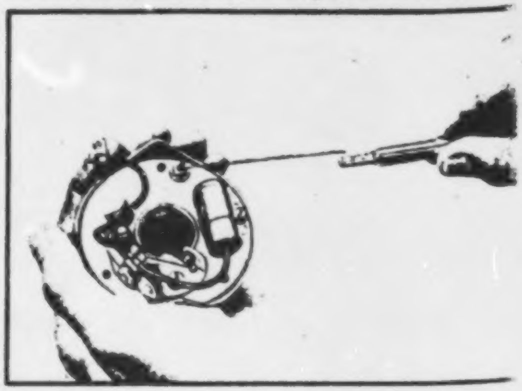

HOOK 1/4" BRASS
DIAL GAUGE
CLAMP ON DISTRIBUTOR HOUSING
PULL TO 5 POUNDS
NOTE-
DISTRIBUTOR SHOULD BE HELD IN A VISE OR TEST FIXTURE

Checking wear of distributor shaft and bushings with dial gauge and spring scale


1/8" DRILL
EXTENSION SLEEVE
.001" TO .002 CLEARANCE

Drilling a hole in new drive shaft for rivet on Prestolite and Chrysler distributor

When cam is assembled, be sure governor weight pins rest against inner ends of both slots as shown



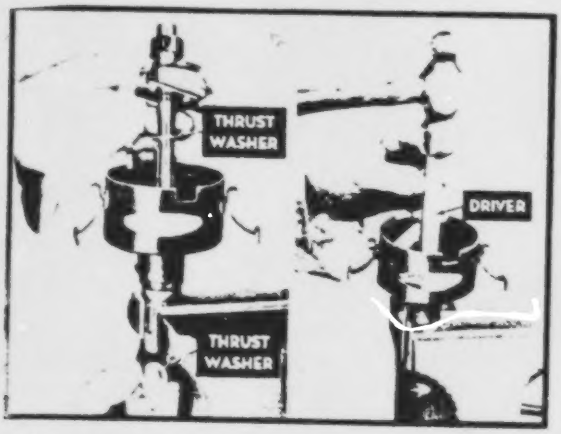
Checking Delco-Remy internal adjustment breaker plate friction with ounce spring scale. The correct pull to move the breaker plate while holding the support plate is usually 11 to 18 ounces

If the interior is dirty or oily, the distributor should be completely disassembled for cleaning and inspection. Any attempt to wash out the distributor without disassembling it will result in getting dirt below the breaker plate where it cannot be blown out.

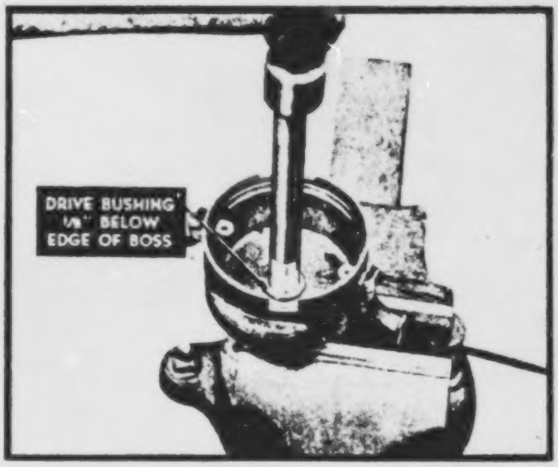
If the automatic advance is not functioning properly or if the breaker plate bearings are rough as determined by the simple checks outlined previously, the distributor must be disassembled and the defects corrected. Likewise, if a check shows that the distributor shaft and bushings are worn excessively, complete disassembly is required in order to install new bushings.

The most accurate method of checking for wear in the shaft and bushings is with a dial gauge and spring scale. With five pounds pull on the scale, maximum wear should not exceed .005". More than .005" wear requires the replacement of the bushing in the distributor housing.

If a dial gauge and spring scale are not available, a fair estimate of the amount of wear may be determined by first turning the shaft so that the breaker points are open. Measure the breaker gap with a round wire feeler gauge. Then push the shaft in the direction which will open the points wider. Hold the shaft in this position and again check the breaker gap. The difference between the first check and the second is the amount of wear present.



Removing shaft and driving out bushing on Prestolite distributor



Driving in distributor shaft bushing on Prestolite distributor

Disassembling Presetolite & Chrysler Distributor

To remove the breaker points, remove the screw and clip which holds the primary lead wire, condenser lead wire and breaker arm sping. Lift the breaker arm off its pivot pin. Remove the retaining lock screw and lift off the contact support.

To remove the vacuum control unit, release the hairpin lock from the vacuum control arm pivot. Remove the screws holding the vacuum chamber to the distributor housing and withdraw the unit from the distributor.

To remove the breaker plate, take out the two screws and bearing retainer clips, which are adjacent to the distributor cap clips, and lift out the breaker plate. The breaker plate may be separated from the sub plate by pushing the two plates apart after disconnecting the attached wire leads.

To expose the governor weights, remove the felt wick from the well of the cam and pick out the lock ring, which fits in a groove on the shaft and holds the cam in position. Lift off the cam, which will expose the governor weights and springs.

Disassembling Delco-Remy Distributor

Internal Adjustment Type. Referring to Fig. 1 , remove the breaker plate ground lead. Unfasten and remove the vacuum control unit. Disconnect the primary terminal connector lead from the terminal stud and remove the stud and bushing.

Remove the three screws which attach the support plate to the distributor housing and lift the breaker plate assembly from the housing. Do not disassemble the breaker plate at this time.

Breaker Plate Bearings

On the Prestolite and Chrysler distributors under discussion here, the movable breaker plate is mounted on a ball bearing. This bearing should be checked before being installed to see that there is no friction in any part of its rotation, due to worn balls or races. If the bearing inner race, which is part of the breaker plate, is loose, no attempt should be make to wedge it in place as this requires special tools to do the job properly. In such cases, replace the breaker plate and bearing assembly.

On some Delco-Remy distributors, the movable breaker plate rotates on three balls located between the outside diameter of the plate and distributor housing. The housing should be inspected for excessive wear in the groove where the balls roll. The indentations in the housing and breaker plate caused by the balls pressing against them. The remedy is to replace the housing and breaker plate.

On other Delco- Remy internal adjustment distributors, a different method is used in mounting the movable breaker plate in the distributor which eliminates the three balls previously used. Note that the breaker plate to which the vacuum advance link is fastened has three bakelite buttons which rest on a support plate which is screwed to the distributor housing. An oil saturated felt between the breaker and support plates assures lubrication for the feet as they move in the support plate with changes in the amount of vacuum advance. A post fastened to the movable breaker plate extends through the slot in the support plate and carries a bearing washer, spring washer, shim washer and stop washer. These, together with one or two retaining washers which snap into a groove in the movable breaker plate hub, hold the two plates together as an assembly. Production tolerances determine if one or two retainer washers are used. The number of shim washers on the post is very important since they must furnish enough pressure against the spring washer to prevent tipping of the movable breaker plate, but not exert so much pressure as to cause excessive friction between the two plates.

Inspect the breaker plate assembly for looseness, which would permit tipping or rattling of the base plate. Normally it is unnecessary to disassemble this unit. However, if it is very dirty it may be disassembled for cleaning and inspection.

Remove the stop washer and shims from the base plate post. Remove the retainer washer from the base plate hub and separate the parts.

When reassembling the breaker plate, saturate the felt washer with 10W engine oil, then install the base plate on the support plate. Place the small side spring in the recess in the support plate so that the two points will be between the ends of the retainer washer when installed. The spring helps to prevent side play of the base plate. Install one retainer washer in the groove of the base plate hub. The hub is staked at four places to provide end play of approximately .015" between the base plate and the support plate. Place the fiber, spring, shim and stop washer on the base plate post in the order named.

Whether the breaker plate has been disassembled or not, attach an ounce spring scale, and check the pull required to move the base plate on the support plate. The pull should be from 11 to 18 ounces. If the pull is less than 11 ounces, add shim washers to the base plate post between the stop and spring washers. If the pull exceeds 18 ounces, remove shim washers as required. This assembly tension is very important in preventing tipping of the base plate and controlling the amount of friction opposing rotation of the base plate on the support.

Information Sheet # 2

Electrical

There are very few electrical tests inside of a distributor in a conventional ignition system. The elctrical tests in an electronic ignition system will be covered in section 12 of this competency.

The electrical tests inside of a distributor are to visually check wires for broken insulation or bad connections, check the condition of the contact points, and to test the condenser. Contact points service is covered in competency E- 13 The following is a procedure for testing a condenser.

There are 3 basic tests of a condenser-service resistance, capacity and leakage. These tests may be made with a condenser test. The general procedure is to:

1. Connect the postive lead of the tester to the condenser lead wire or connect the negative lead to the case of the condenser.
2. Read the service resistance.
3. Turn the tester to "Capacity Test" and read the meter.
4. Turn the tester to "Leakage Test" and read the meter.

NOTE: If this test is performed in the car, the points must be blocked open.

Usually the condenser is replaced each time the contact points are replaced.

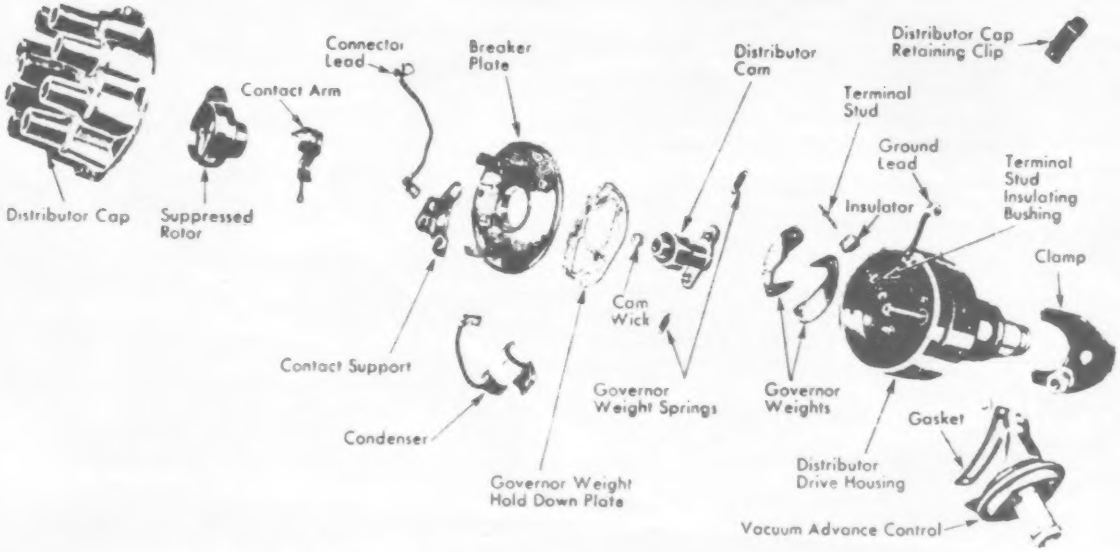

Connector Lead
Breaker Plate
Contact Arm
Distributor Cam
Distributor Cap Retaining Clip
Terminal Stud
Ground Lead
Terminal Stud Insulating Bushing
Insulator
Distributor Cap
Suppressed Rotor
Clamp
Cam Wick
Contact Support
Governor Weight Springs
Governor Weights
Gasket
Condenser
Distributor Drive Housing
Governor Weight Hold Down Plate
Vacuum Advance Control

Fig. 1 *Exploded view of a Delco-Remy internal adjustment distributor*

DISTRIBUTOR ADVANCE MECHANISMS

To provide the proper spark advance or retard to fit all speeds and throttle openings, most distributors are equipped with both a vacuum advance and a centrifugal advance unit. These may stick, wear out, or become defective in other ways.

QUICK TESTING CENTRIFIGUAL ADVANCE

If the distributor is on the car, disconnect the vacuum line to the vacuum advance. Run the engine slowly from an idle up to around 4,000 rpm and use a timing light to watch the timing mark. It should advance smoothly against the direction of engine rotation. When the action is jerky, stop the engine, remove distributor cap and twist the rotor in the direction of rotation. When the rotor is released, it should snap back to the original position. A slow return indicates a gummy or corroded advance unit. Clean and oil. A loose rattle-type condition indicates broken or stretched return springs. Replace. Distributor should then be checked out, using distributor tester.

QUICK TESTING VACUUM ADVANCE

Disconnect vacuum advance line. Start engine and run at a steady 1,200 rpm. Note position of the timing mark (use a power timing light) in relation to the pointer. Connect vacuum advance line. When line is connected, the timing mark should immediately move against the direction of engine rotation (advance). If nonoperative, remove distributor and test on distributor machine. In addition to the vacuum unit, check for a sticky breaker plate.

TEST TOOLS FOR CHECKING DISTRIBUTOR ON CAR

Test tools are available for checking the degree of advance provided by either or both the vacuum or centrifugal units. If checks indicate repairs are needed, the distributor should be removed, repaired and checked on a distributor tester. Tools used would be a timing light with the degrees of advance meter on it, a tachometer and a vacuum source (hand pump or from a distributor testing unit),

ADJUSTING VACUUM ADVANCE

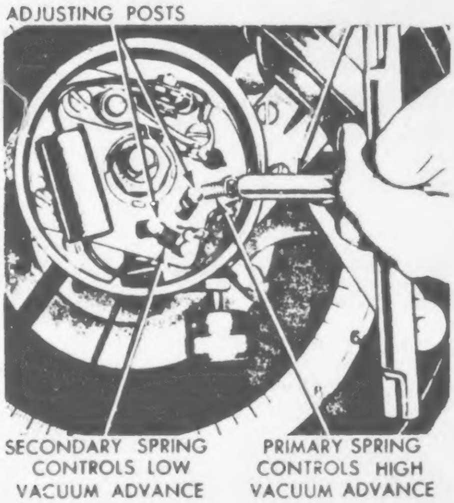
Some vacuum advance units are nonadjustable and must be replaced. Others provide spacer washers that may be added or removed to vary the spring tension.

Following adjustment (on either vacuum or centrifugal advance unit), the distributor must be carefully checked against specifications on an accurate distributor test machine.

Such a machine may be used to check the distributor for dwell, point bounce, bent shaft, worn bushing, worn cam, vacuum and centrifugal advance, etc.

ADJUSTING CENTRIFUGAL ADVANCE UNIT

The centrifugal advance unit should be clean and lightly oiled. Adjustment posts are provided to vary spring tension to bring the advance curve (relation between degree of advance and engine rpm plotted from idle to a high rpm) within specifications.


ADJUSTING POSTS
SECONDARY SPRING CONTROLS LOW VACUUM ADVANCE
PRIMARY SPRING CONTROLS HIGH VACUUM ADVANCE

Adjusting centrifugal advance unit.

Electrical Competencies - Ignition Service

No. E-7 Testing - Distributor

Worksheet # 1

Name ______________________ Date __________ Grade __________

DISTRIBUTOR TESTING MACHINE

NOTE: This sheet is to be used if a distributor testing machine is available.

Year and Make ______________ ______________

Name of Owner ______________________________

Suggested Test Sequence

1. Mount the distributor into a fixture.
2. Test the contact points for resistance.
3. Test for poor insulation and leakage.
4. Test the contact-point spring tension.
5. Do the dwell test.
6. Test for spring-tension reaction while in operation.
7. Check the mechanical condition of the distributor.
8. Test the centrifugal advance.
9. Test the vacuum advance.

Check-out Sheet

Name of Distributor ______________ Rotation on top end __________

Model Number of Distributor ______________ Point gap __________ in.

Dwell __________ degrees Point spring tension __________ oz.

Specifications	Results
Points spring tension __________ oz	Points spring tension __________ oz.
Dwell __________ degrees	Dwell at 400 distributor rpm __________ degrees
	Dwell at 1,000 distributor rpm __________ degrees (Should be within 4°of the 400 rpm reading.)
Centrifugal-advance specifications (distributor rpm and degrees):	Centrifugal-advance results(distributor rpm and degrees):
Advance starts ________ degrees at ________ rpm	Advance starts ________ degrees at ________ rpm
Full advance ________ degrees at ________ rpm	Full advance ________ degrees at ________ rpm
Vacuum-advance specifications:	Vacuum-advance results:
Start plunger movement ________ in. Hg	Start plunger movement ________ in.Hg
Maximum advance ________ degrees at ________ in.Hg	Maximum advance ________ degrees at ________ in.Hg

Any service necessary on distributor ______________________________

____

Instructor's Initials __________

Electrical Competencies - Ignition System

No. E-7 Testing - Distributor

Worksheet # 2

Name ______________________________ Date __________ Grade ________

DISTRIBUTOR OVERHAUL

Before completing any of the operations on this worksheet, the distributor should be tested with a dial indicator, timing light, tachometer, and vacuum pump, or a distributor tester.

Tools needed: Hammer, bushing driver, reamer, drift punch, screwdriver, pliers and shop manual.

Make of Distributor ______________________________ Model # ____________

Parts needing replacement

	Yes	No
Upper Bushing	____	___
Lower Bushing	____	___
Distributor Shaft	____	___
Distributor Housing	____	___
Distributor Cam	____	___
Breaker Plate	____	___
Centrifugal Advance Weights	____	___
Centrifugal Advance Springs	____	___
Vacuum Advance	____	___

Instructor's Initials __________

AUTO MECHANICS

Electrical Competencies

No. E- 8 Ignition Coil Testing

OBJECTIVE: After competion of this unit the student will be able to test successfully ignition coils from both conventional and electronic ignition systems.

EXPLANATION: The function of the ignition coil is to develop a voltage high enough to jump the spark plug gaps under all conditions. If the coil starts to weaken, a car can become very unreliable and troublesome.

MATERIALS NEEDED: coils,pencil, specifications, and automobile

TOOLS NEEDED: voltmeter, ohmmeter, jumper lead, ammeter

References	Do
#1. p. 21-4 to 21-7	1. Study information sheets
#2. p. 53-54	2. Complete with 100% accuracy the Ignition Coil Polarity Test sheet.
#3. p. 476-479	
#4. p. 396-398	3. Complete with 100% accuracy the Ignition Coil Test Worksheet.
#5. p. 206-207	
#6. p. 302-304	
#7. p. 265	
#8. --	

Electrical Competencies- Ignition Systems

No. E- 8 Ignition Coil Testing

Information Sheet # 1

Ignition Coil Service

Ignition coils do not normally require any service except to keep all terminals and connections clean and tight. In addition, the coil should be kept reasonably clean but it must not be subjected to steam cleaning or similar high pressure cleaning methods which may cause moisture to enter the coil. Moisture inside of any ignition coil is probably the principal factor that determines coil life. Ignition coils are subjected to rain, snow and road splash. Also, some moisture gets inside the coil from condensation and the normal breathing of the coil caused by temperature change.

The high tension terminal socket may be corroded as a result of arcing by previous failure to properly insert the end of the cable into the socket. Corrosion may also develop in sea coast areas due to the salt air.

Any corrosion will cause resistance to the flow of current. Therefore, the socket should be thoroughly cleaned with a special terminal cleaner, Fig. 1 , with sandpaper wrapped around a pencil or with a suitable stiff wire brush. Clean the cable terminal with sandpaper.

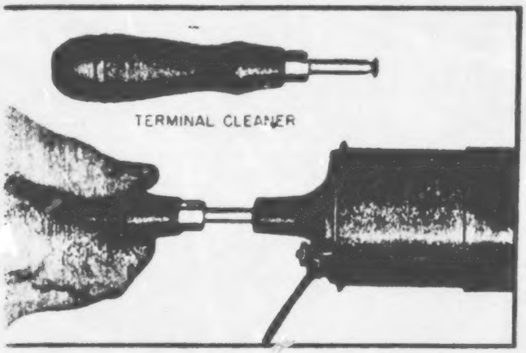


Fig. 1 Cleaning high tension terminal socket of coil with special cleaner made for the purpose. This tool is also used for cleaning out distributor cap cable sockets. Sandpaper wrapped around a pencil will also do an adequate job

Causes of Coil Failure

As mentioned above, moisture inside of any ignition coil is an important factor determining its life. But premature coil failure is caused by several other conditions, the chief reason being the same high voltage which burns breaker points.

The ignition coil, like the rest of the car's electrical system, is designed to operate efficiently at 6-8 or 12-14 volts depending on the system. Even with this normal voltage, a certain amount of heat develops in the coil, as heat is the natural result of current flowing through any conductor.

With a high-voltage condition, however, the increased voltage naturally causes an increase in the current flowing through the coil and, consequently, an increase in heat. But the really bad part of it is that the heat developed is proportional to the square of the current- not to the current itself. In other words, an increase of one-half in current will produce more than twice the heat.

This is exactly what happens to a coil on a car with high voltage. Considering a car with a 6-volt system as an example it is not unusual to find that the voltage is 10 volts, which is one-third increase over the normal 7 1/2 volts. In such cases, the heat developed in the coil is about twice the normal, and the coil must overheat.

Any coil that is subjected to twice the normal heat for any length of time will gradually weaken, as the high heat will char the insulation in the secondary winding and cause internal shorts. Eventually the coil will fail completely.

Therfore, in most cases where you find burnt breaker points on a car, the coil is also liable to go bad as both conditions are caused mostly by high voltage. If the coil does go bad under these conditons, it will do no lasting good to install a new coil unless the cause of the high voltage condition is found and corrected.

Another cause of coil failure is an abnormal strain put upon the secondary winding of the coil by resistance in the high tension circuit. This can be caused by a defective radio suppressor, wide gaps between spark plug electrodes (due either to wrong adjustment or natural burning away of the electrodes in service) or a burnt rotor segment. In any one of these cases, the coil is compelled to develop an abnormal amount of voltage in order to overcome the additional resistance, and this abnormal voltage often breaks down the insulation between the layers of the secondary winding.

The above conditions may even cause the spark to jump between the high tension and the primary terminals of the coil, over and along the bakelite top. It is a well known electrical characteristic that all electrical currents travel in the path of least resistance. Therefore, whenever the resistance of the spark plug gap under compression plus the resistance of the defective unit becomes greater than the resistance of the insulation between the high tension terminal and the primary terminal the spark will jump there instead of the spark plug gap. This is especially true in damp weather, due to moisture on the bakelite top which reduces the electrical resistance there, or when grease or dirt are present on the coil top. The metallic particles in the dirt also provide a path of low resistance for the spark. Besides, any moisture that would dry up on a clean coil top will keep the dirty top damp.

Sometimes the spark jumps right through the bakelite of a high tension terminal at a point opposite a primary terminal. You will find in most of such cases that the high tension cable is not all the way in the socket.

Leaving the ignition key on overnight or for a long time is another frequent cause of coil breakdown. In this case, the uninterrupted current through the primary overheats the coil and damages the insulation. After a period of time, this will cause the coil to fail.

Importance Of Correct Coil Polarity

As you know if you have studied the chapters on Magnetism and Electricity, polarity means the quality of having opposite pole. In a magnet, for instance, there is a north pole and a south pole. A battery has a positive pole and a negative pole. Although it has been established that the flow of current in a wire is from the negative to the positive, the practice of considering that electric current flows from positive to negative has been established in textbooks and service station work for so many years that it is advisable to go along on that assumption. Therefore, so far as we are concerned with the automotive electrical system, the principle to remember is that current flows from the positive pole to the negative pole.

Let us apply this principle to ignition coil operation and performance. In the automotive electrical system, the battery is connected either by grounding the negative post or grounding the positive post. Where the ground is on the negative post of the battery, all operating electrical units are connected to the positive side of the battery, and the current flows from the live (ungrounded) post of the battery, through the units and back through the chassis of the car (the ground), which is connected to the negative post of the battery, Fig. 2.

Where the positive post of the battery is grounded, the current flows in the opposite direction- through the chassis, then through the units, and back into the battery (Fig 3)

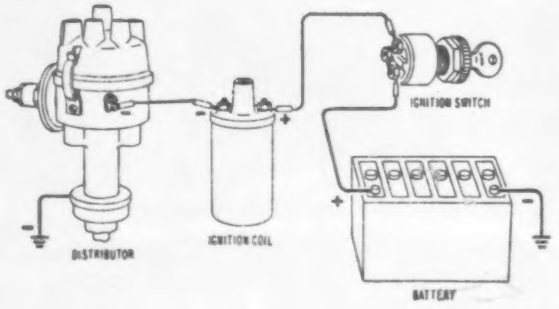


Fig. 2 Wiring connections for coil with negative grounded system

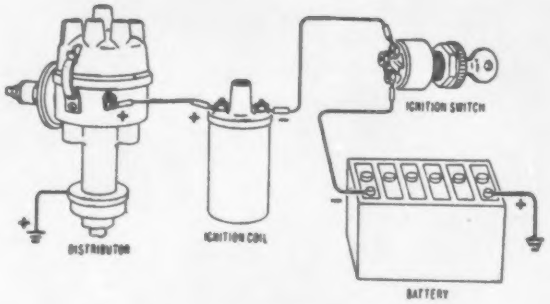


Fig. 3 Wiring connections for coil with positive grounded system

It has been conclusively established that the high tension spark in the combustion chamber jumps with greater ease if the live (center) electrode of the spark plug is of negative polarity. As the live electrode of the spark plug is connected directly to the high tension winding of the ignition coil, it follows that the ignition coil must be so constructed internally that the end of the high tension winding, which is connected to the spark plug, be of negative polarity.

From the above, it must not be deduced that an ignition coil will not operate unless the live end of the secondary winding is of negative polarity. What will happen if the polarity is wrong is that the efficiency of the coil will drop 15% or more, and while this may not have an apparent effect under normal operating conditions, it most certainly will be felt if conditions demand the maximum coil efficiency. For instance, in cold weather starting, wrong coil polarity has often resulted in failure to start, something that always haunted the winter driver. It is that 15% loss in efficiency, when conditions require peak performance, that is the decisive factor in such cases.

Checking Coil Polarity

Most coils are marked positive and negative at the primary terminals. When installing or connecting a coil be sure to make the connections as shown in Figs. 2 and 3.

If perchance the coil is not marked as to its polarity, it can be checked by holding any high tension wire about 1/4" away from its spark plug terminal with the engine running. Insert the point of a wooden lead pencil between the spark plug and the wire, Fig. 4. If the spark flares and has a slight orange tinge on the spark plug side of the pencil, polarity is correct. If the spark flares on the cable side, coil connections should be reversed.

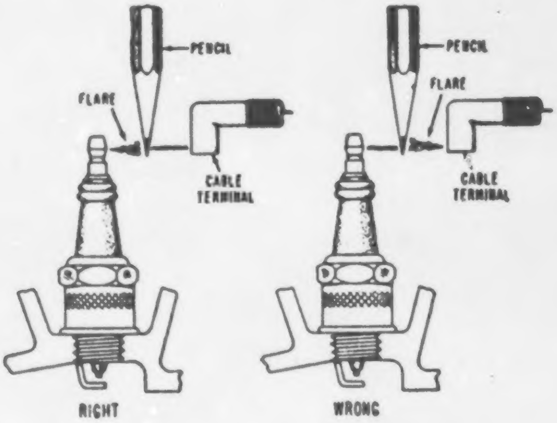


Fig. Checking coil polarity

Another method of checking coil polarity can be done easily with a voltmeter as follows:

1. Connect the voltmeter positive (+) lead to the engine ground.

CAUTION: Do not puncture spark plug cables or boots with a sharp probe.

2. Connect an adapter with an exposed terminal into any spark plug cable either at the plug or the distributor. If a spark plug terminal is accessible, an adapter is not required.

3. Start and idle the engine.

4. With the voltmeter set on the highest scale, momentarily touch the negative (-) lead to the plug terminal or adapter.

5. If the meter needle swings up scale, polarity is correct. If the needle swings down scale, polarity is reversed. The voltage reading does not matter.

The most common cause of reversed polarity is reversed connections at the coil. If the cable connections are reversed at the battery, electrical system polarity will also be reversed.

Ignition Coil Tests

If poor ignition performance is obtained and the coil is suspected, it may be tested on the car or it may be removed for the test.

Ignition coils are often condemned when the trouble is actually in the ignition switch. A completely defective ignition switch will produce an open primary circuit, giving the same indication as if the coil were completely dead. A partly defective ignition switch will cause a weak spark. Both of these conditions are often blamed on the coil.

By cutting the ignition switch out of the circuit, it can easily be determined whether or not the coil is defective or whether the fault lies with the ignition switch.

A wire should be connected to the terminal of the coil to which the battery wire is normally connected, Fig. 5 This temporary connection jumps the ignition switch. If the trouble is eliminated when the engine is started, it is obvious that the ignition switch was the offender- not the coil.

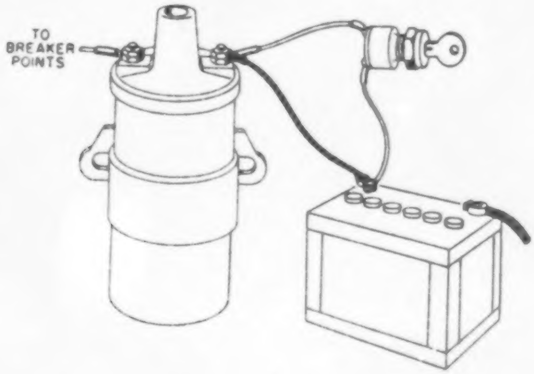
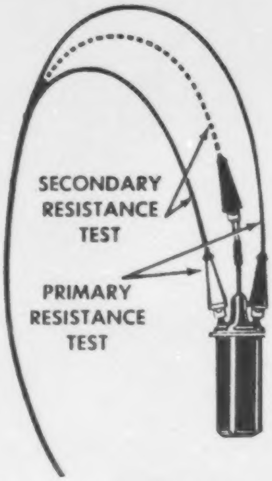


Fig. 5 Temporary connection to cut ignition switch out of circuit when checking operation of ignition coils

Winding Resistance Test

Measure the resistance of the primary and secondary windings as follows:

1. Be sure the ignition is off.
2. Set the ohmmeter on the low scale. (calibrate ohmmeter)
3. Measure the primary resistance by connecting the ohmmeter leads to the primary terminals. Compare the meter reading to the car maker's specifications. (See insert)
4. Set the ohmmeter on the highest scale. (calibrate ohmmeter)
5. Measure the secondary resistance by connecting one ohmmeter lead to the high-tension tower terminal and the other lead to first one primary terminal, then the other. (See insert)
6. Note the lowest reading and compare it with the manufacturer's specifications.
7. Replace the coil if the primary or secondary resistance is out of limits.



Shorted Winding Test

Test the coil for shorted windings by setting the ohmmeter on the low scale and connecting one lead to either primary terminal. Touch the other lead to the metal case of the coil and observe the meter. There should be no reading (infinite resistance). Any reading at all indicates the coil windings are shorted to the case, and the coil must be replaced.

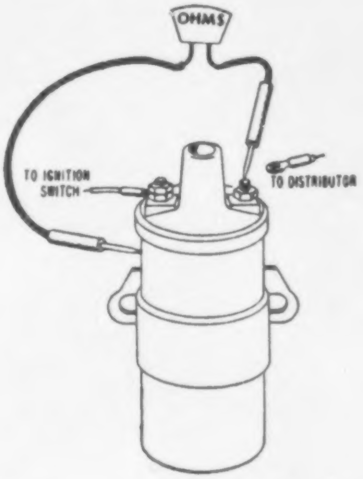


Fig. 6

Current-Draw Test

Many car makers provide current-draw specifications for their ignition coils. Specifications may be given with the ignition on, points closed, and engine not running or with the engine running at a specified speed.

Observing the correct polarity, connect an ammeter in series with the coil and observe the reading. A low reading indicates a discharged battery, high resistance in the primary wiring or the primary coil winding, or loose or corroded connections. A high reading usually indicates shorted coil windings, a shorted ballast resistor, or the incorrect coil for the car. (Fig. 7)

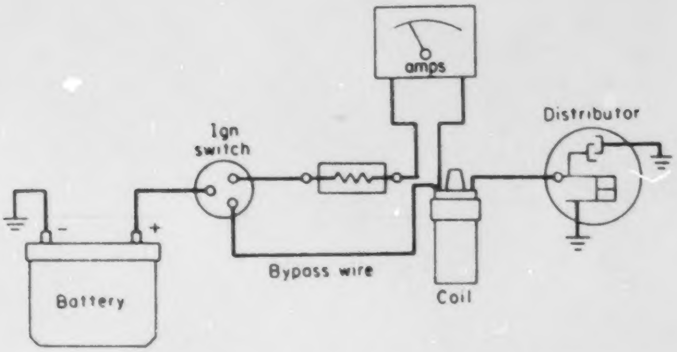


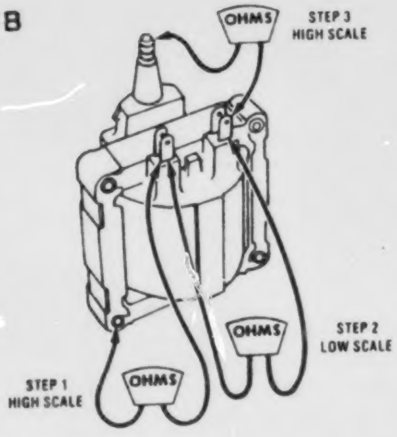
FIGURE 7 Ammeter connected into the ignition primary circuit.

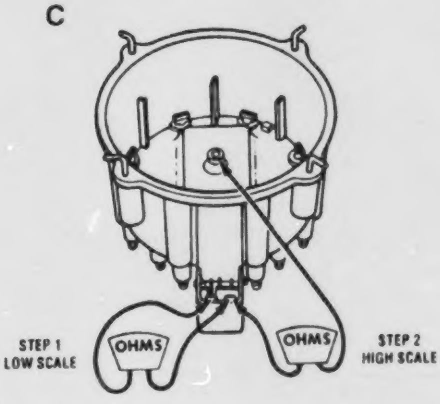
Simple Ignition Coil Check

In the absence of any testing equipment a simple check of the ignition coil can be made as follows: Turn on the ignition switch with breaker points closed. Remove the high tension cable from the center socket of the distributor cap and hold it about 3/8" away from a clean spot on the engine. Then open and close the breaker points with an insulated screwdriver. If the coil and other units connected to it are in good condition a spark should jump from the wire to the engine. If not, use a jumper wire from the primary terminal of the distributor to the engine; if the primary is in good condition a spark will occur.

Testing General Motors High Energy Ignition Coils

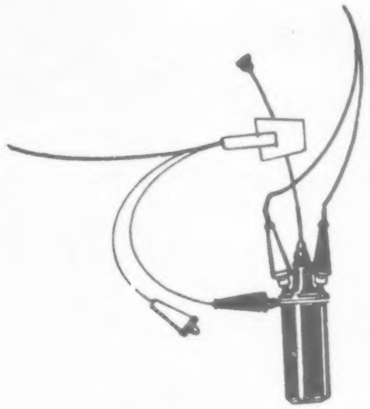
DIAGRAM REFERENCE	PROCEDURE	VOLTMETER OR OHMMETER READINGS		
		ACCEPTABLE	HIGHER	LOWER
B	For 4 and L-6 engines. Connect ohmmeter as in diagram **B**. Ignition Switch OFF Step 1. High Scale Step 2. Low Scale Step 3. High Scale	1. Infinite 2. 0.5 to 1.0 3. 6,000-30,000	1. — — 2. Replace Coil 3. Replace Coil	1. Replace Coil 2. — — 3. Replace Coil
C	For V-6 and V-8 engines. Remove Cap. Spark Plug wires need not be removed. Connect ohmmeter as in diagram **C**. Ignition Switch OFF Step 1. Low Scale Step 2. High Scale	1. 0.5 to 1.0 2. 6,000-30,000	1. Replace Coil 2. Replace Coil	1. — — 2. Replace Coil


B
OHMS
STEP 3
HIGH SCALE
OHMS
STEP 2
LOW SCALE
STEP 1
HIGH SCALE
OHMS


C
STEP 1
LOW SCALE
OHMS
OHMS
STEP 2
HIGH SCALE

Testing Ignition Coils Using The "Sun" 947 Oscilloscope

The Ignition Coil Test circuit is used in conjunction with the ignition scope to conduct the coil test. The coil test is accomplished by the use of the COIL TEST selector, Calibrator, and the black cable test leads. The test result is observed on the Ignition Scope. Six, twelve or twenty-four volt coils can be tested. One test is made for shorts, opens, grounds, and insulation breakdown.



1. Plug the AC cord into correct power outlet.

2. Place the AC switch on the right side of the headframe to the ON position.

3. Place coil in the coil holder. NOTE: Coil may be tested on the vehicle by removing vehicle's primary leads and high tension lead.

4. Connect black cable leads to coil primary terminals. Observe polarity.

5. Blue Cable:
   a. Clamp chrome pattern pickup around a high tension wire inserted into the coil tower.
   b. Connect the black ground lead to the coil holder (or to the engine block if coil is tested in the vehicle.

6. Rotate OHM-COIL CALIBRATOR fully counterclockwise.

7. Adjust scope as outlined in the scope section of this manual. turn the CIRCUIT SELECTOR switch to the SECONDARY position and PATTERN SELECTOR to the DISPLAY position.

8. Hold COIL TEST selector counterclockwise to STANDARD COIL for conventional ignition coils or clockwise to TRANSISTOR COIL for transistor ignition coils.

9. Adjust the PATTERN LENGTH control until a complete single waveform is expanded across the screen.

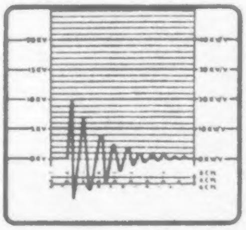
10. Rotate OHM-COIL calibrator clockwise until the highest portion of the waveform reaches 20 KV.

NOTE: If the first oscillation of the waveform points down reverse the test leads to the coil primary.

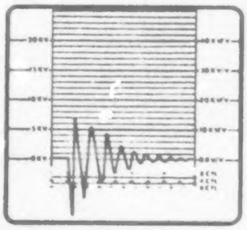
11. Observe waveform and observe oscillations.

Results and Indications

Waveform height is 20 KV or more, and oscillations are similar to those in the illustration; ignition coil is in satisfactory condition.

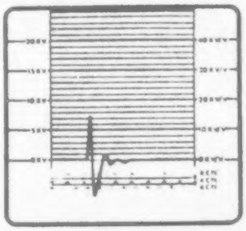


NORMAL

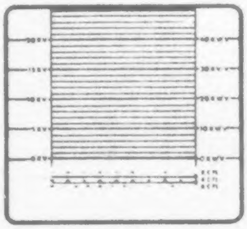


REVERSED POLARITY

First oscillation extending downward instead of up; reversed polarity indicated.



SHORTED



OPEN

Waveform height is 20 KV or less and few oscillations are seen; coil is defective due to shorted primary or secondary winding or internal insulation breakdown.

Waveform height is 20 KV or more, but pattern is unstable or "jittery", coil is defective due to internal insulation breakdown.

Waveform is a straight line; coil has open primary winding.

Electrical Competencies - Ignition Systems

No. E- 8 Ignitions Coil Testing

Worksheet # 1

Name ____________________ Date ______________ Grade __________

Coil Polarity Check - Out Sheet

Good Bad

What side of the pencil did the spark occur?

plug side ______

cable side ______ ______ ______

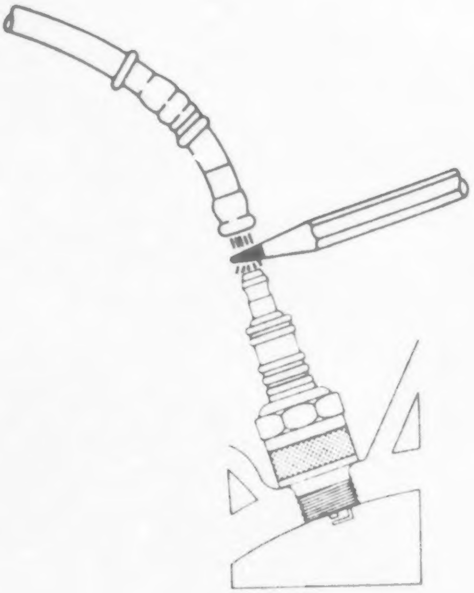
Is the battery properly grounded?

negative ______

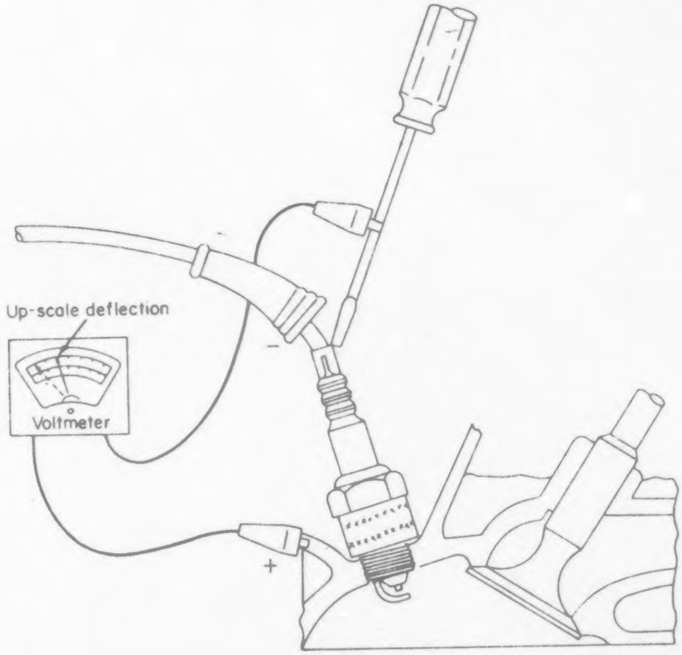
positive ______ ______ ______

Did the voltmeter needle climb?

upscale ______ or down scale ______ ______ ______



Checking coil polarity with a lead pencil.



Checking coil polarity with voltmeter.

Instructor's Initials __________

Electrical Competencies - Ignition Systems

No. E- 8 Ignition Coil Testing

Worksheet #2

Name ______________________ Date ______________ Grade ____________

Ignition Coil Test Checksheet			Good	Bad
Ignition Switch Bypass Test			____	____
Primary Resistance Test				
	Specification	________		
	Results	________	____	____
Secondary Resistance Test				
	Specifications	________		
	Results	________	____	____
Shorted Winding Test			____	____
Current-Draw Test				
	Specifications	________		
	Results	________	____	____
Simple Coil Test				
	Sharp blue spark at least 3/8"		____	
	Wide yellow spark shorter than 3/8"			____
	No Spark		____	____
Oscilloscope Coil Test			____	____

Instructor's Initials__________

If the cable is stretched, the core may be broken with no evidence of damage on the outer insulation. The terminal may also be pulled off the cable. If the cable core is broken or the cable terminal is not securely fastened to the cable core, it will produce an engine miss which is identical in effect to a defective spark plug.

Many late-model cars, particularly those with electronic ignition systems, have suppression-type ignition cables or cable boots made with a silicone insulation material. The silicone material is said to provide better high-voltage insulation and to resist heat and moisture deterioration better than rubber or other materials.

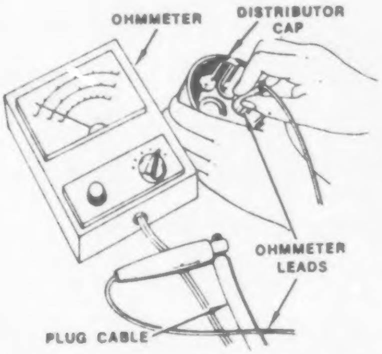
Silicone insulation material is softer and more pliable than other materials and is more likely to be torn or scuffed by rough handling. Never puncture silicone cables or boots with a probe when taking test readings. When removing silicone-type cables from spark plugs, it is very important to turn the cable and boot carefully until broken loose from the plug. Never pull on the cable.

The Delco HEI system uses special silicone-type cables that are 8mm in diameter. Conventional cables have a 7mm diameter. Use of any conventional 7mm, suppression-type cable on the Delco HEI system is not recommended.

Spark Plug Cable Service

Spark plug cables can be tested for high resistance or lack of continuity with an ohmmeter as follow:

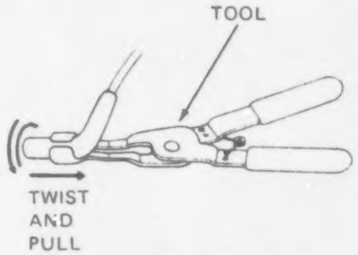
1. Remove the cables from the plugs.
2. Lift the cap from the distributor. Do not remove the cables from the cap.
3. To test suppression-type cables, set the ohmmeter on the R x 1000 range.
4. Connect the ohmmeter from the spark plug terminal to the corresponding terminal inside the cap.



5. Compare the meter reading to the car maker's specifications for cable resistance. Specifications are usually given in ohms per foot of cable length.
6. To test metallic cables, set the ohmmeter on the lowest range. A metallic cable should have no resistance.

Replace a complete set of spark plug cables as follows:

1. Starting at the front of the engine, remove one cable from the distributor cap and a spark plug.



Removing cables from spark plugs with a special tool.

2. Cut the new cable to the proper length and install the terminals.

3. Be sure the cap tower is clean and free of corrosion. Insert the new cable into the cap so that the terminal is firmly seated and the rubber boot seals over the tower. Squeeze the boot to release air trapped in the tower.

4. Install the spark plug end of the cable on the plug. Be sure the connector is seated firmly on the terminal and the boot seals the plug insulator.

5. Repeat the above steps to install the other cables. Be sure all cables are routed as originally placed by the car maker to avoid crossfiring and cable damage.

6. Secure the cables in their holders and be sure that the cables do not touch hot exhaust manifolds.

CAUTION: Never remove cable and nipple assemblies from the distributor or coil towers unless (1) the nipples are damaged or (2) cable testing shows the cables are bad and must be replaced. You can ruin a cable by careless removal and installation.

CAUTION: Do not puncture cables or nipples with test probes. Puncturing cable insulation or a nipple can ruin the cable. The probe can separate the conductor and cause high resistance. Also, breaking the insulation can result in high-tension leakage to ground. Either of these can cause engine miss.

Electrical Competencies - Ignition System

No. E-9 Testing-High Tension Leads

Worksheet # 1

Name ______________________________ Date ____________ Grade __________

NOTE: Average resistance is 4,000 ohms/ft.
Manufactures specifications ______________ohms/ft.

1. Remove cables from spark plugs.
2. Lift the cap from the distributor.
3. To test suppression-type cables set ohmmeter on the R x 1,000 range.
4. Connect the ohmmeter from the spark plug terminal to the corresponding terminal inside the cap.
5. Compare the meter readings to the car makers specifications for cable resistance.
6. To test metallic cables, set the ohmmeter on the lowest range. A metallic cable should have no resistance.

Coil High Tension Wire Resistance ____________________ohms

Spark plug wire resistance

1.____ 2._____ 3.______ 4.____ 5._____ 6.______ 7.______ 8.______

NOTE:
Results and Indications

Ohmmeter reads zero:
Steel or copper ignition wire system-indication normal.

Ohmmeter reads between 5000 ohms and 25,000 ohms:
Suppression system or as specified by manufacturer - indication is normal.
Regular wire system - high resistance wire or cap connection. Remove wire and test as in Ohmmeter tests.

Ohmmeter reads greater than 25,000 ohms:
Suppression or regular wire system.
Wire or cap connection resistance too high. Remove wire and test as in Ohmmeter Tests.
Replace faulty wire or clean distributor cap tower.

Instructor's Initials ______________

AUTO MECHANICS

Electrical Competencies- Ignition Systems

No. E-9 Testing-High Tension Leads

OBJECTIVE:

Upon completion of this competency, the student will be able to successfully test ignition high tension cables.

EXPLANATION:

High tension cables with excessive resistance can cause an engine to misfire, resulting in poor performance and economy.

MATERIALS NEEDED:

Automobile, a set of high tension cables
Pencil

TOOLS NEEDED:

Ohmmeter

References	Do
#1. Ch. 21	#1. Read assigned reference.
#2. Ch. 3	#2. Study Information Sheets.
#3. p. 473-543	#3. Complete Worksheet No. 1.
#4. p. 395-426	#4. Have instructor approve.
#5. p. 201-227	
#6. p. 310-321	
#7. p. 259-281	
#8. --	

Electrical Competencies - Ignition System

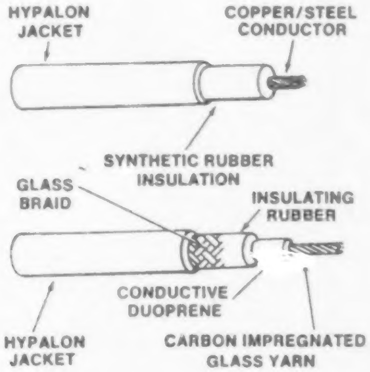
No.E- 9 Testing-High Tension Leads

Information Sheet # 1

Ignition Cables

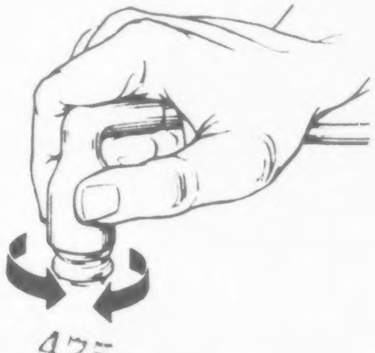
The ignition cables carry the high-voltage current from the coil to the distributor cap and from the cap to the spark plugs. Years ago, all ignition cables were made with copper or steel wire as the conductor. During the past 10 to 20 years, metallic-conductor cables have been replaced by suppression-type cables that have a carbon, or carbon-impregnated linen, core.

Suppression-type cables are also called resistance cables because they increase the reistance in the secondary circuit. The higher resistance suppresses high-frequency electrical impluses that would interfere with radio and television transmission.


HYPALON JACKET
COPPER/STEEL CONDUCTOR
SYNTHETIC RUBBER INSULATION
GLASS BRAID
INSULATING RUBBER
CONDUCTIVE DUOPRENE
HYPALON JACKET
CARBON IMPREGNATED GLASS YARN

Suppression-type cables also prolong spark plug life by reducing the current flow across the electrodes. Although metallic-conductor cables are still made and sold for special applications, they are not used as original equipment by any domestic or foreign vehicle makers and their use is not recommended on any late-model passenger cars or light trucks.

Suppression-type cables are more easily damaged than metallic-conductor cables. Therefore, the cables must be removed from spark plugs with care. Grasp the rubber spark plug boot and gently twist it to break the seal between the boot and the plug. Then gently lift the boot from the plug. Never jerk the cable or try to disconnect it by pulling on the center of the cable.



AUTO MECHANICS

Electrical Competencies- Ignition Systems

No. E-10 Testing Distributor Cap and Rotor

OBJECTIVE:

Upon completion of this competency the student will be able to successfully recognize defective distributor caps and rotors.

EXPLANATION:

With prolonged use and exposure to a wide variety of operating conditions, distributor caps and rotors become cracked, corroded, eroded, and contaminated causing poor engine performance and economy.

MATERIALS NEEDED:

automobile
good lighting (flashlight, troublelight, etc.)

TOOLS NEEDED:

screwdriver
wire brush suitable for terminal cleaning

References	Do
#1. Ch. 21	#1. Read assigned references
#2. Ch. 3	#2. Study information sheets.
#3. p. 476-543	#3. Visually inspect an automobile's distributor cap and rotor.
#4. p. 395-426	#4. Chack with instructor.
#5. p. 201-227	
#6. p. 310-321	
#7. p. 259-281	

Electrical Competencies- Ignitions Systems

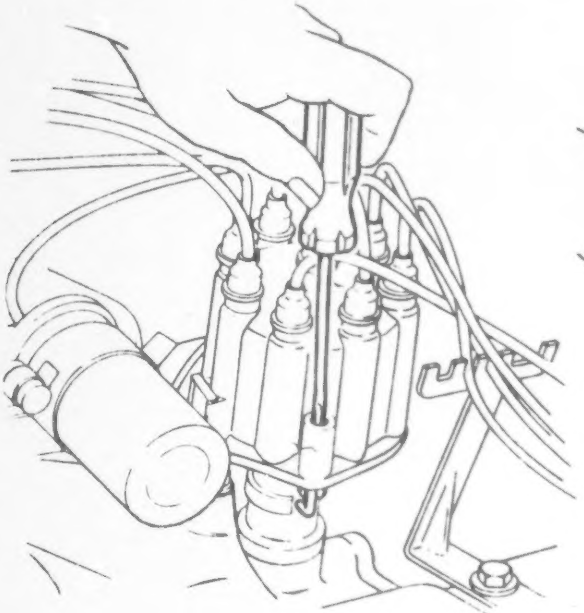
No. E-10 Testing Distributor Cap and Rotor

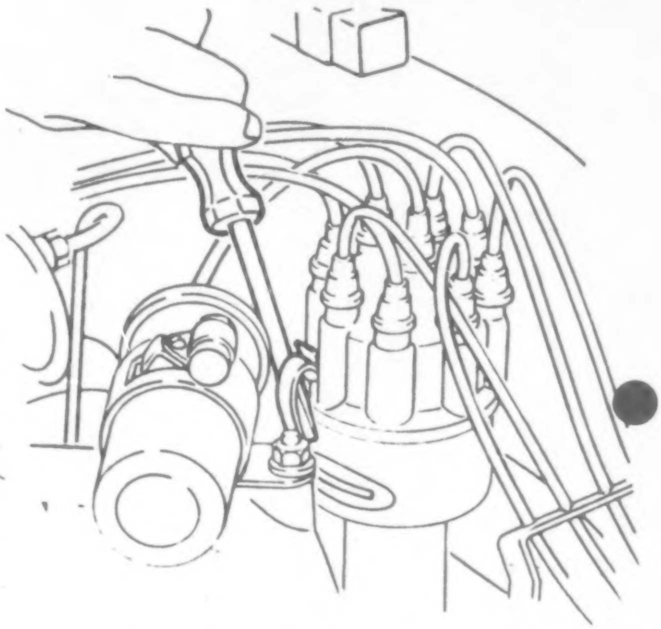
Information Sheet # 1

Distributor Cap and Rotor Service

1. To remove the cap from a distributor containing spring loaded screw clamps, press down on the screw and turn in either direction to release clamp from the distributor housing so cap can be removed.

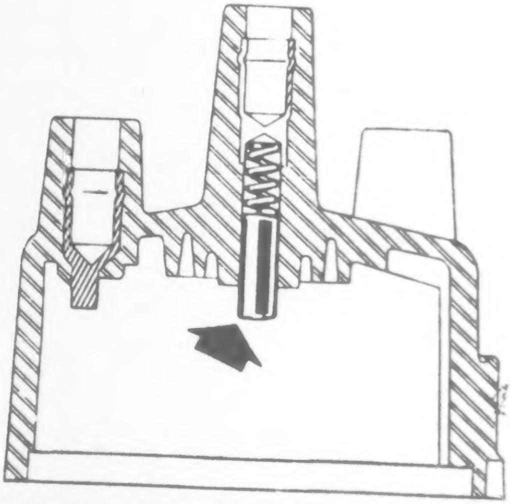
2. To remove the cap from a distributor containing spring clips, place a screwdriver between the spring clip and distributor housing and pry outward. Do not apply screwdriver pressure to the cap itself as this might crack the cap.

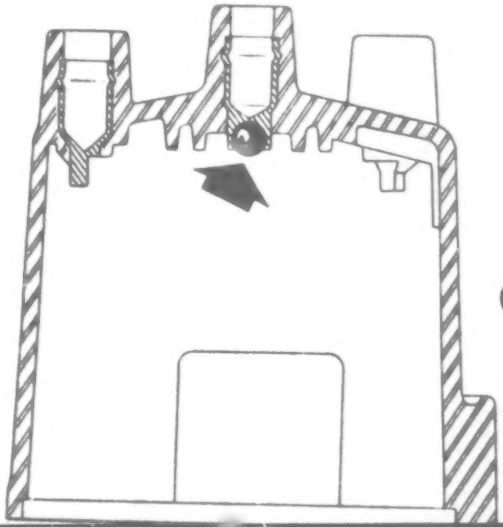




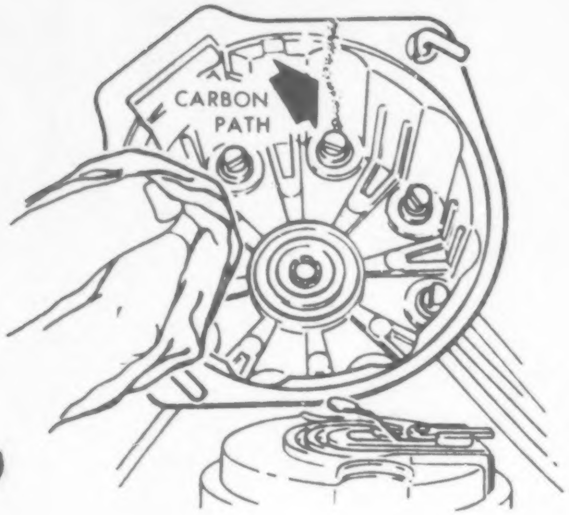
3. Inspect caps having a spring loaded rotor button for freeness of movement of the button. Excessive wear of the button should also be noted, and the cap replaced, if necessary, as discussed in later pages.

4. Caps having a solid rotor button should be examined for excessive wear of the button, chips or cracks. If these defects are found, replace cap as discussed in later pages.

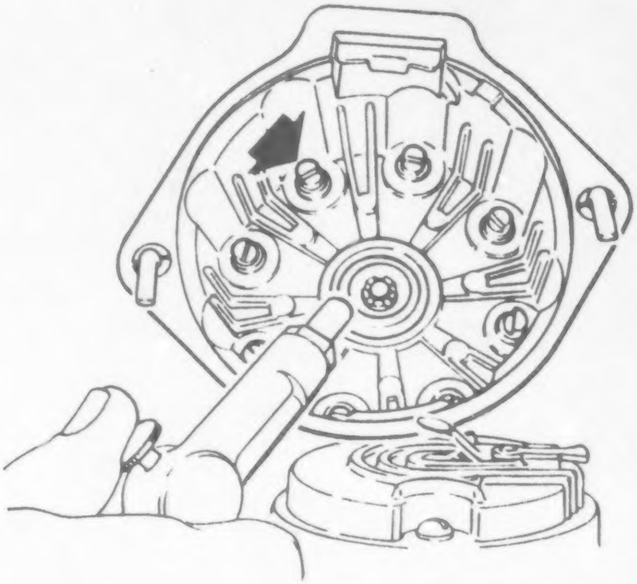




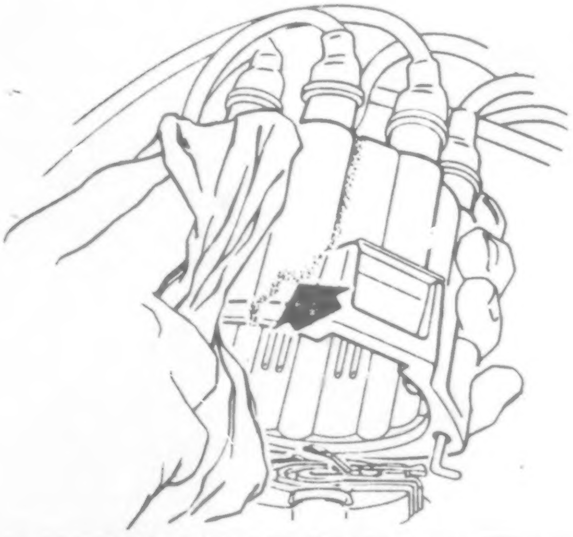
5. Wipe the inside of distributor cap with a clean cloth dampened in solvent and inspect cap for carbonized paths, which will allow high tension leakage to ground, and for chips and cracks. Such defects require replacement of the cap which will be discussed later.



6. Dry inside of cap with an air hose. Check for badly burned or eroded inserts and replace cap if necessary. Corroded inserts should be scraped clean to maintain a low resistance path for current flow.

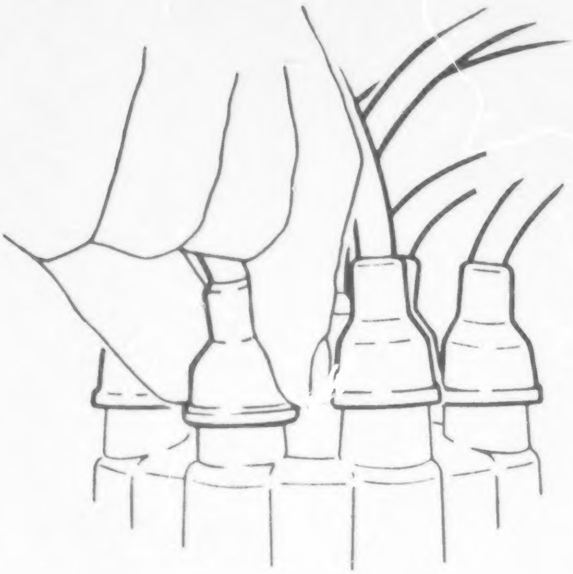


7. Clean exterior of cap with a clean rag and solvent. Check for chips, cracks and carbonized paths. Such defects indicate the need for cap replacement.

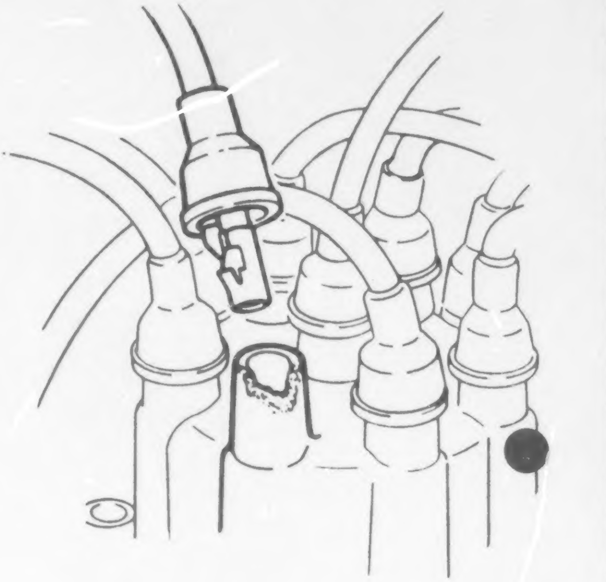


8. Press down firmly on each lead to make sure it is all the way down in the tower. All leads should be tight and snug when properly placed in their tower.

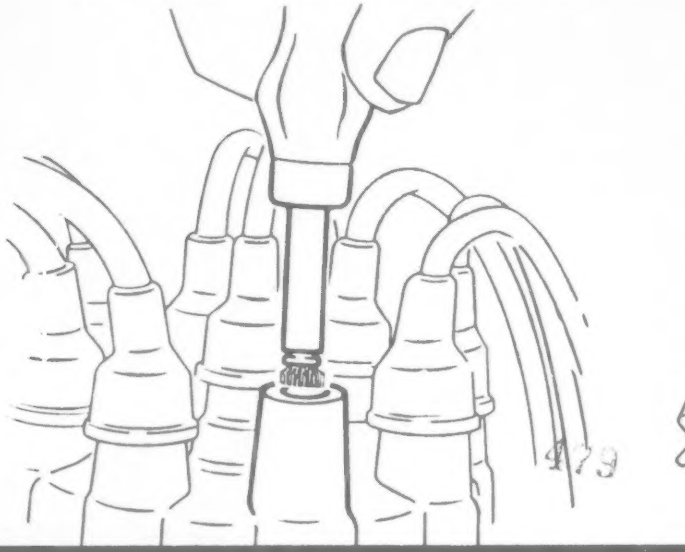
9. Check rubber boots to make sure they are down and tight around each tower. An improperly positioned boot may push lead up in tower and result in a poor electrical connection.



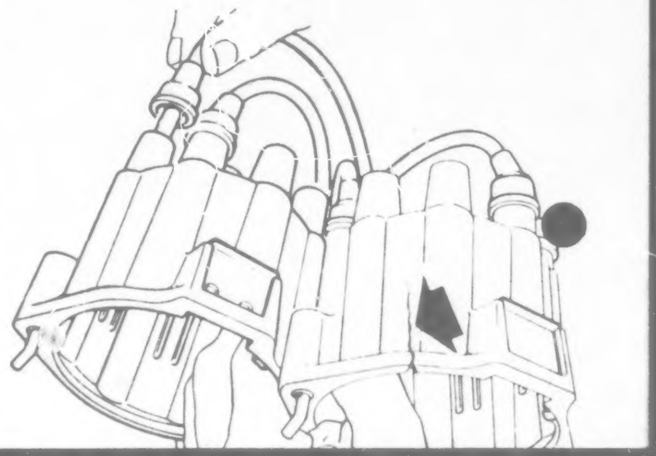
10. If any leads are loose in their tower, remove them one at a time to determine if metal clip is securely fastened to end of lead of if tower is eroded. Lead or cap replacement may be required.



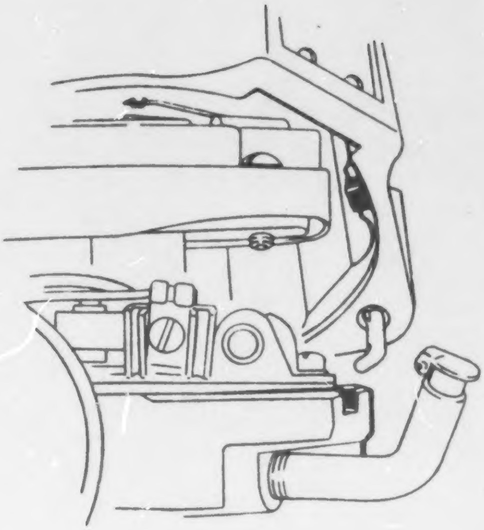
11. If a tower with a loose lead appears to be in good condition except for minor corrosion, the tower insert may be cleaned with a wire brush or by some other suitable means. Removing the corrosion may uncover a major defect that may indicate the need for replacement.



12. To replace a defective cap, place old and new caps side by side in same relative position noting locating lugs or slots. Remove one lead at a time from the old cap, placing it in the same relative tower on the new cap. Lead must first be pushed to bottom of tower and then the rubber boor replaced securely.

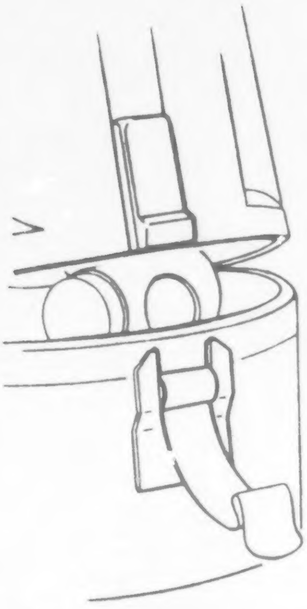


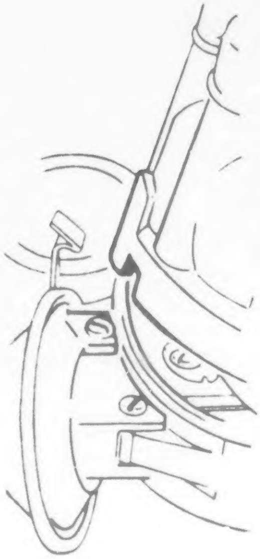
13. To properly locate cap on distributor bowl, some types of distributors have a locating lug on the cap that matches a corresponding slot in the distributor housing when the cap is reinstalled.

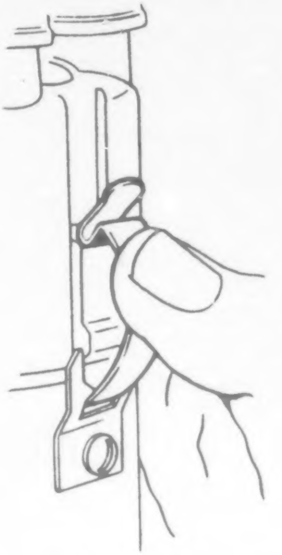


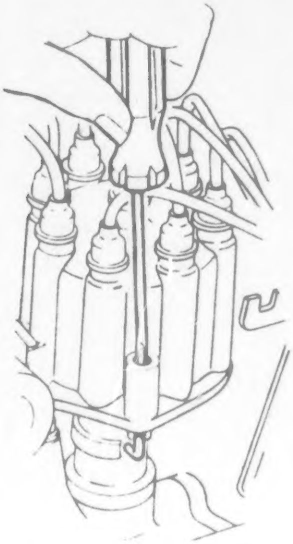
14. Other types of distributors have either; a locating lug that fits into a slot in the cap spring hanger-- or a groove or slot in the cap that fits over a boss on the distributor housing.

15. After replacing the cap, with the locators in place, fasten it to the housing by either: pressing on center of cap spring forcing spring over mounting lugs on cap- or by pressing down on screw and turning until clamp is under slot on bottom of housing.





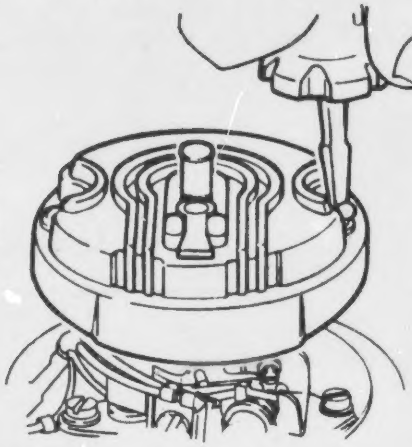




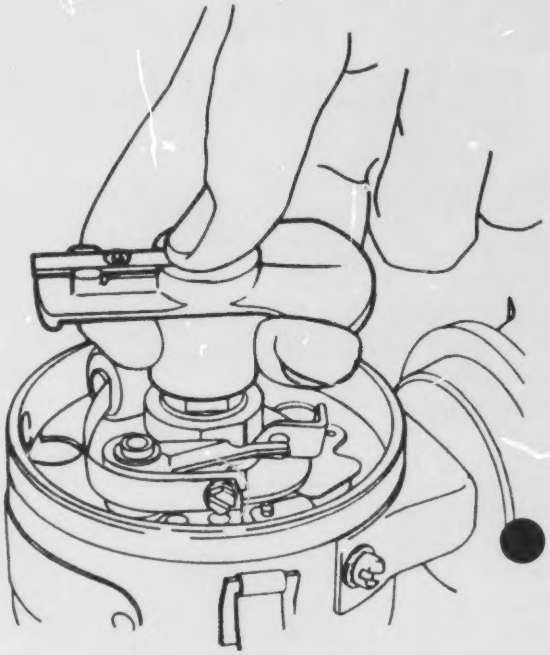
DELCO-REMY DIV., GENERAL MOTORS CORP.

16. On the type distributor shown, the rotor is released by removing the screws.

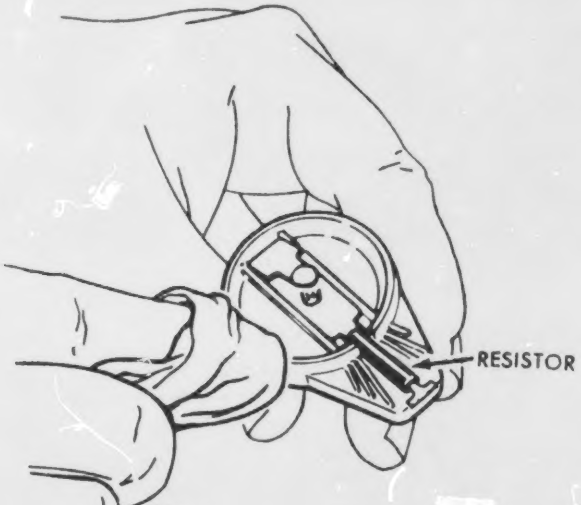
THE FOLLOWING SECTION COVERS THE REMOVAL, INSPECTION AND INSTALLATION OF DISTRIBUTOR ROTORS.



17. Removal of other types of rotors is accomplished by pulling up.



18. To clean the rotor, wipe off dirt using a clean rag dampened in solvent. Then examine rotor for cracks or chips and inspect rotor tip for excessive burning. If the rotor tip is badly corroded, scrape it clean. Check spring on rotor for sufficient tension to insure good contact with carbon button in center of distributor cap. The carbon resistor, if present, should be examined for cracks. Rotor replacement may be indicated.



AUTO MECHANICS

Electrical Competencies - Ignition Systems

No. E-11 Testing- Spark Plugs

OBJECTIVE:

After completion of this unit, the student will be able to examine a spark plug and identify any variation from proper engine function or spark plug function.

EXPLANATION:

Many engine malfunctions may be identified by examining the spark plugs. Spark plug service can usually be identified by looking at the condition of the electrodes.

MATERIALS NEEDED:

TOOLS NEEDED:

References	Do
#1. Ch. 21	#1. Read assigned reference.
#2. Ch. 3	#2. Study worksheet.
#3. p. 473-543	#3. Study some spark plugs to identify the running condition of the engine and the condition of the spark plug.
#4. p. 395-425	
#5. p. 201-227	#4. Check with the instructor.
#6. p. 310-321	
#7. p. 259-281	

Electrical Competencies- Ignition System

No. E-11 Testing- Spark Plugs

Information Sheet #1

Spark Plugs

There are several methods for testing spark plugs but the most common are visual inspection, spark plug tester or an oscilloscope pattern. Usually on an oscilloscope, a fouled spark plug will show a rather short firing line and a spark plug with worn electrodes will show a long firing line. A spark plug tester will show how the spark plug will fire under pressure. The following section deals with the visual inspection.

Spark Plug Diagnosis

The ability to examine plug electrodes and the insulator to determine the plug operating conditions is a critical part of spark plug service. This is often called "spark plug reading." The following photographs are examples of spark plugs operating under various conditions and showing common causes of failure.

Normal

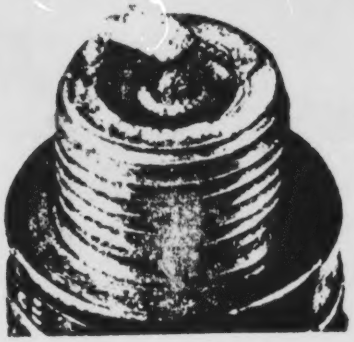
A light brown or gray-tan color on the insulator and clean electrodes indicate a spark plug that is operating at the correct temperatures for a specific engine and type of driving.

Too Hot

Both electrodes are eroded and the insulator is white and free of deposits. The insulator tip may be blistered or cracked. This is due to the heat range of the plug being too hot for the engine operating conditons. Contributing factors may be overadvanced timing, a heat riser valve stuck closed, or an overly lean fuel mixture.

Carbon Fouled Or Too Cold

Dry, dark carbon deposits on the electrodes, the insulator, and inside the shell generally indicate that the plug temperature is too low for the engine conditions.

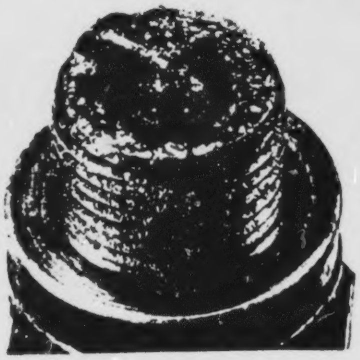


Possible causes are:
- Overly rich fuel mixture
- Retarded timing
- Excessive choking
- Heat riser valve stuck open
- Low engine temperature
- Excessive idling and low-speed driving

If a plug appears to have been operating too hot or too cold, do not overlook the possibility that plugs of the wrong heat range were installed in the engine.

Oil Fouled

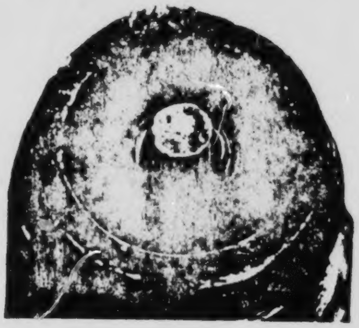
Dark, wet deposits on the electrodes, insulator and shell indicate an oil-fouled plug. Oil fouling may be caused by several kinds of engine wear, including old age.



The use of spark plugs one or two heat ranges hotter than specified for the engine will slow down the oil fouling but will not cure the problem.

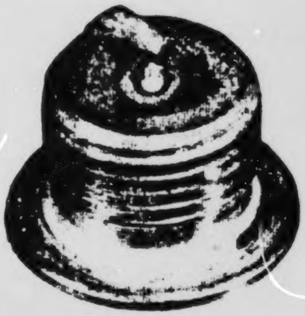
Detonation

Detonation, or spark knock, occurs where overadvanced ignition timing or low-octane fuel causes combustion conditions that result in severe mechanical shock. These explosive, hammer-like blows can damage the piston or spark plug and may eventually fracture the electrode.



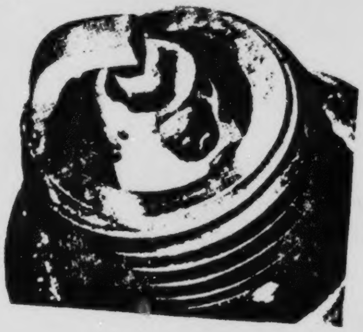
Turbulence Burned

The shape of some combustion chambers causes the hot combustion gases to always flow over the tip of the plug in the same direction at high speed velocity.



Splash Fouled

Splash fouling is caused by deposits breaking loose from pistons and valves and "splashing" against hot plug insulators where they weld tight. Sufficient splash fouling may short out the plug.



Core or Gap Bridged

Core bridging is usually due to the same conditions as Splashed Fouling. The difference is largely in degree. The excessive deposits form a bridge between the insulator and the shell, producing a dead short. This is most common in engines where oil control is poor, or which are used in slow-speed, start-stop service.

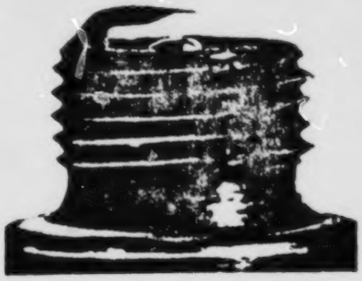
This splashing can also bridge the gap across the electrodes and short out the plug.

Chipped Insulator

A cracked or broken insulator usually results from bending the center electrode to set the spark gap. Bend the side electrode only to avoid damage of this kind. Under certain conditions a chipped insulator may result from severe detonations.

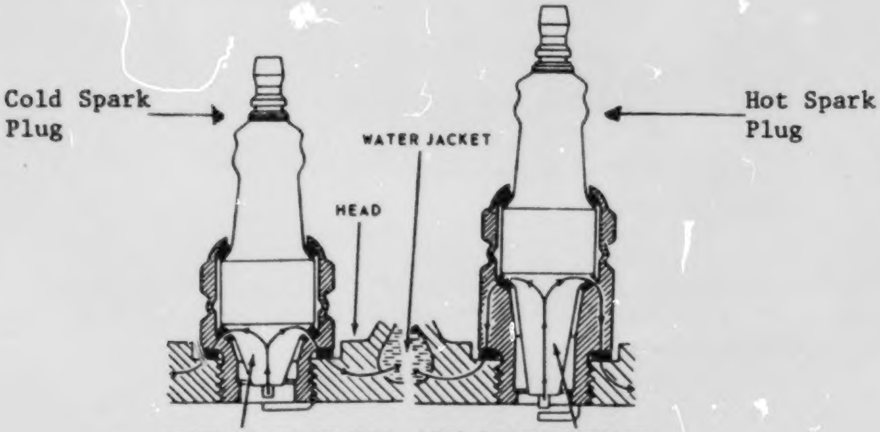
Worn Electrodes

Worn center and ground electrodes show that plug has given its full service life. Excessive and rapid deterioration of the ground electrode may be due to reversed polarity.



Heat Ranges:

It is a poor practice to change heat range from manufacturers specifications as severe engine damage may result.



SHORT, HEAVY INSULATOR TIP CONDUCTS HEAT UP TIP, THROUGH SEAL, INTO SHELL, THROUGH GASKET INTO HEAD AND WATER JACKET. PLUG RUNS COLD.

LONG, THIN INSULATOR TIP IS A POOR CONDUCTOR. HEAT MUST TRAVEL FURTHER TO ESCAPE. PLUG RUNS HOT.

Spark plug heat range.

For worksheets on Testing, Servicing and Adjusting spark plugs, turn to Electrical Competencies E-13of this packet.

AUTO MECHANICS

Electrical Competencies- Ignition Systems

No. E-12 Testing Electronic Control Modules

OBJECTIVE:

After completing this unit the student will be able to test electronic ignition control modules.

EXPLANATION:

The electronic control modules, magnetic pickups, and other circuit components used in solid-state ignitions can malfunction. As an automotive mechanic you should be able to test and detect a malfunctioning component.

MATERIALS NEEDED:

Electronic ignition control modules or vehicle equipped with electronic ignition system.

TOOLS NEEDED:

Voltmeter
Ohmmeter
Jumper Wire
Test Light

References	Do
#1. Ch. 21, p. 31-33	#1. Read assigned reference.
#2. p. 67-70	#2. Read information sheets.
#3. p. 536-543	#3. Do worksheet #1.
#4. p. 412-424	#4. Do worksheet #2.
#5. p. 211-213	#5. Do worksheet #3.
#6. p. 298-301, 315	#6. Have instructor's approval.
#7. p. 274-281	
#8. --	

Solid-State Ignition Troubleshooting

Solid-state ignition systems differ from breaker-point systems in the methods used to control the primary circuit. Secondary circuit operation in solid-state systems still relies on the conventional induction coil to produce high voltage to fire the plugs. Therefore, secondary ignition circuit testing and service with solid-state systems is basically the same as with breaker-point systems.

Breaker points are the weakest links in conventional ignitions and the parts that need the most frequent service. By eliminating the points, solid-state ignitions have become almost maintenance free. In most systems, dwell angle, or the period when the primary circuit is on, is controlled by a solid-state electronic module. The dwell period cannot change due to wear of the rubbing block or cam lobes. Dwell angle, or period, is usually a fixed design factor and cannot be altered. Dwell angle measurements, although they can be made, are not significant on most systems. The dwell period, or angle, on some systems changes with engine speed.

Service of electronic ignition systems is not the periodic replacement of points and condenser or adjustment of dwell. The new concept in service is that of testing and fault diagnosis. The electronic control modules, magnetic pickups, and other circuit components used in solid-state ignitions can malfunction. Service consists of electronic troubleshooting followed by component replacement.

Circuits can be tested with oscilloscopes, special circuit testers, or simple volt-ohmmeters. Always check the specifications and follow the procedures of the ignition and test equipment manufacturers.

The following paragraphs contain basic troubleshooting procedures, using common test equipment, for Delco-Remy, Chrysler, Ford, and AMC-Prestolite electronic ignitions.

Electrical Competencies - Ignition System

No. E-12 Testing - Electronic Control Modules

Information Sheet # 1

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The following paragraphs contain basic troubleshooting procedures, using common test equipment, for Delco-Remy, Chrysler, Ford, and AMC-Prestolite electronic ignitions.

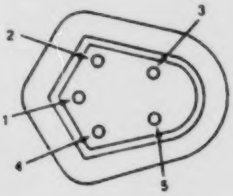
Troubleshooting The Chrysler Electronic Ignition System

Basic troubleshooting of the Chrysler electronic ignition can be preformed with a voltmeter and an ohmmeter. These tests will help you isolate failures in the ignition primary circuit.

CAUTION: Do not touch the switching transistor on the control unit when ignition switch is on. Sufficient voltage is present to produce a shock.

1. Check all primary and secondary wiring and connections for cracks, breaks, and looseness.

2. Measure and note available battery voltage.



WIRING HARNESS CONNECTOR CAVITIES

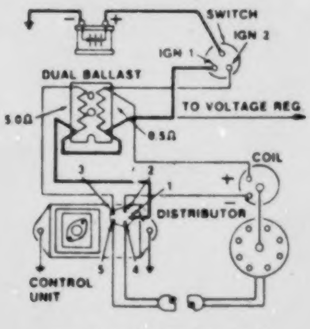
3. Measure distributor air gap with a nonmagnetic feeler gauge and adjust if necessary.

4. With ignition switch off, remove the multiwiring connector from the ignition control unit.

CAUTION: The ignition switch must be off whenever the connector is removed from or connected to the control unit.

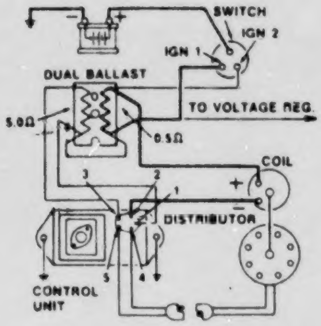
5. Turn the ignition switch on and connect the negative lead of your voltmeter to a good ground.

6. Connect the voltmeter positive lead to harness connector cavity No. 1. With ignition switch on and all accessories off, available voltage should be within 1 volt of battery voltage. If voltage is not within 1 volt of battery voltage, trace the circuit shown.



Circuit for Connector No. 1

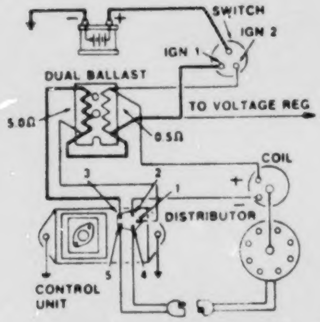
7. Repeat step 6 at harness connector cavity No. 2. If voltage is not within 1 volt of battery voltage, trace the circuit shown.


SWITCH
IGN 2
IGN 1
DUAL BALLAST
TO VOLTAGE REG.
5.0Ω
0.5Ω
COIL
+
−
3
2
1
DISTRIBUTOR
5
4
CONTROL UNIT

Circuit for Connector No. 2

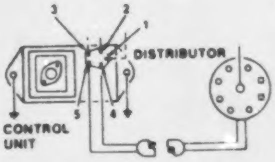
8. Repeat step 6 at harness connector cavity No. 3. If voltage is not within 1 volt of battery voltage, trace the circuit shown.

9. Connect an ohmmeter to harness connector cavities No. 4 and No. 5. The resistance should be within the manufacturer's specified limits.


SWITCH
IGN 2
IGN 1
DUAL BALLAST
TO VOLTAGE REG
5.0Ω
0.5Ω
COIL
+
−
3
2
1
DISTRIBUTOR
5
4
CONTROL UNIT

Circuit for Connector No. 3

10. If the resistance is higher or lower than specified, disconnect the dual-lead connector from the distributor and check the resistance through the pickup coil in the distributor.



11. If the reading in step 10 is still out of limits, replace the pickup coil. If the reading is within limits, check the wiring from the control unit to the dual-lead connector.

12. Connect one ohmmeter lead to ground and the other lead to either side of the dual-lead connector on the distributor. The ohmmeter should indicate an open circuit. Any continuity indicates a grounded pickup coil which must be replaced.

13. Connect on ohmmeter lead to ground and the other to control unit connector pin No. 5. The ohmmeter should show continuity between ground and pin No. 5. If continuity does not exist, tighten the control unit mounting bolts and retest. If continuity still does not exist, replace the control unit.

14. If no defects are found by the voltmeter and ohmmeter tests, remove the coil high-tension lead from the distributor and hold it about 1/4 inch from a good ground. Crank the engine.

15. If sparking does not occur, replace the control module and repeat the test.

16. If sparking still does not occur, replace the ignition coil.

Additional resistance tests can be made with an ohmmeter on the ignition coil and the dual ballast resistor. All tests should be made at a temperature of 70 to 80°F. Check the manufacturer's specifications for coil type, year of car, and coil resistance values. Resistance values for the dual ballast resistor are as follows:

Compensating resistor (coil side), 0.50 to 0.60 ohms.

Auxiliary resistor (control unit side0, 4.75 to 5.75 ohms.

Troubleshooting The Ford Breakerless Solid-State Ignition

As explained in the preceding chapter, wire color coding is the key to tracing the primary circuit of the Ford solid-state ignition. Color coding is summarized below.

White--Voltage supply, cranking
Red -- Voltage supply, running
Orange & purple - Distributor pickup signals
Green-- Primary current, coil to module
Black --Ground
Blue--System protection

Basic primary circuit tests can be made with a voltmeter, an ohmmeter, and a jumper wire. Refer to the connector illustration to determine socket numbers and wire color coding for various years. Perform the tests listed in the appropriate troubleshooting table. Before testing the primary circuit, however, make these preliminary checks:

1. Be sure that all connections are clean and secure at the coil. the control module, and the distributor.

2. Be sure that all high-tension cables are secure at the coil, the distributor cap, and the spark plugs.

3. Test the coil output by removing the coil high-tension wire from the distributor cap, holding it 1/4 inch from a good ground, and cranking the engine. You should get a strong. regular spark.

4. Perform a spark intensity test at each spark plug by removing the cable, holding it near a ground, and watching for a spark while cranking the engine.

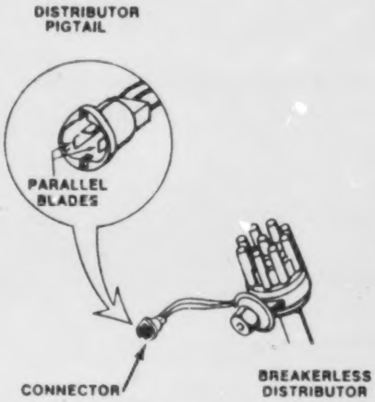
CAUTION: When making a spark intensity test, do not pull the No. 1 and 5 wires on a 6-cylinder engine or the No. 1 and 8 wires on an 8-cylinder engine and allow these cylinders to operate in an open-circuit condition. The magnetic pickup coil in the distributor is located directly beneath these plug terminals in the cap. Opening the circuits to these plugs may allow the rotor to crossfire to the pickup coil and damage the assembly.

5. Also inspect the distributor cap, rotor, coil tower, and cables for cracks, moisture, and other damage.

If the preliminary checks do not locate the ignition problem, test the primary circuit. All tests at the control module 2- or 3-wire and 4-wire connectors are made on the harness side (socket side0 of the connectors. All tests at the distributor connector are made on the distributor side (blade side) of the connector.

Prepare for the following tests by disconnecting both connectors at the module and connecting the negative lead of your voltmeter to a good engine ground.

All connectors in the primary circuit of the Ford solid-state ignition should be lubricated and protected with a conductive luricated and protected with a conductive lubricant such as Lubriplate D.S. or equivalent.



The Ford solid-state ignition system is protected against all known electrical currents on the vehicle. However, the ignition may be damaged by some kinds of charging system tests. Ford recommends volt-ohm test equipment for the charging system. Ford cautions against use of volt-amp equipment or equipment employing a knife switch at the battery. Many pieces of equipment are compatible with Ford electrical systems. Older equipment may need modification. Follow your equipment maker's instructions.

Electrical Competencies - Ignition System

No. E-12 Testing - Electronic Control Modules

1973-74

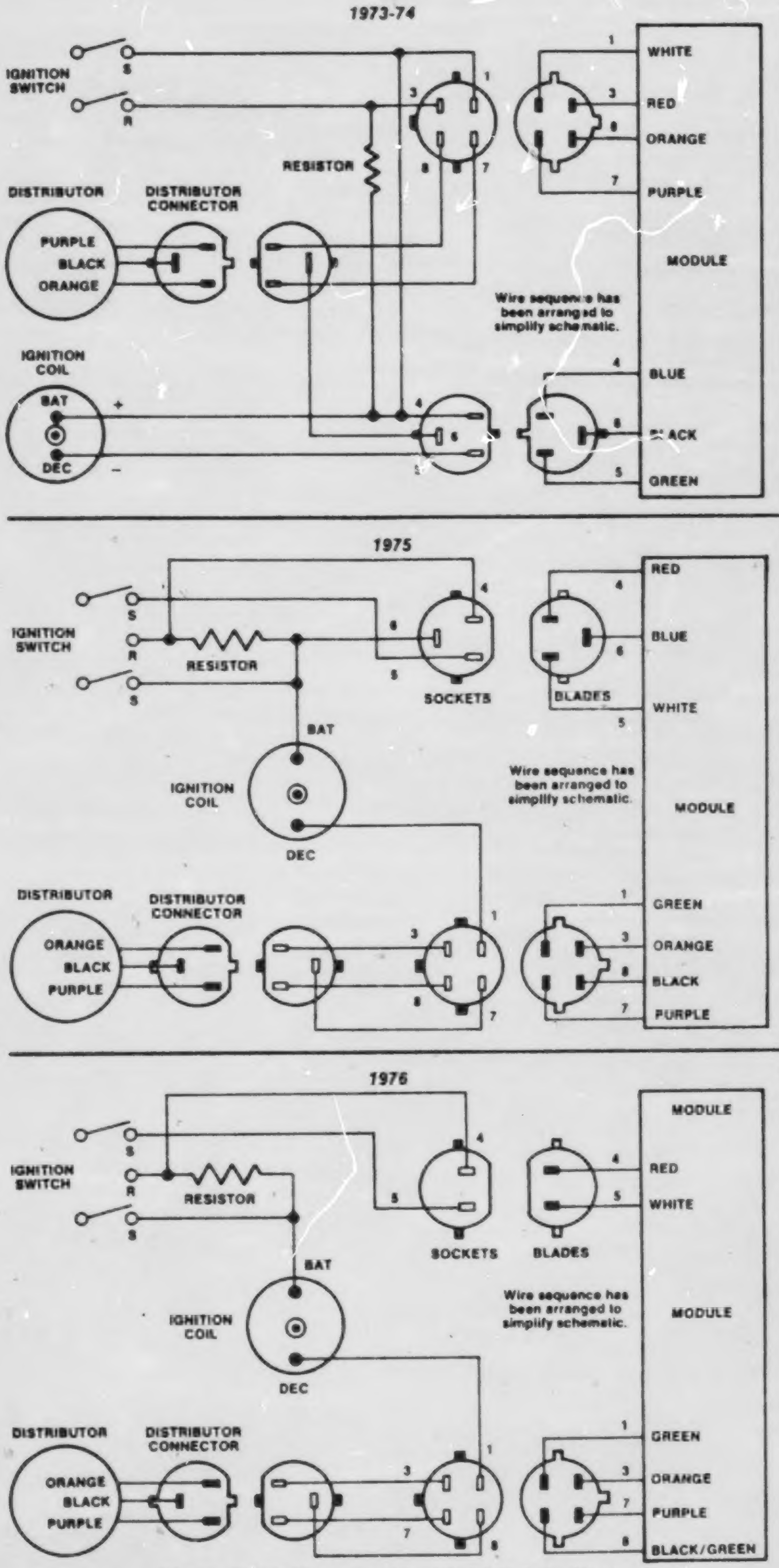
	Test Voltage Between	Should Be	If Not
Key On	Coil BAT terminal and ground. (Module connected, DEC to terminal grounded)	4.9 to 7.9 volts	Low reading - Check primary wiring High reading - Replace resistance wire
	Socket 3 (Red) and ground	Battery voltage ± 0.1 volt	Repair red wire, check connectors
	Socket 5 (Green) and ground	Battery voltage ± 0.1 volt	Check green wire to coil, check coil
Cranking	Socket 1 (White) and ground	8 to 12 volts	Repair white wire, check connectors
	Socket 5 (Green) and ground	8 to 12 volts	Check green wire to coil, check bypass circuit
	Socket 7 (Purple) and Socket 8 (Orange)	0.5 volt ac or any dc voltage	Replace magnetic pickup (stator)
	Test Resistance Between	**Should Be**	**If Not**
Key Off	Socket 7 (Purple) and Socket 8 (Orange)	400 to 800 ohms	Replace magnetic pickup (stator) or repair ground connection
	Socket 6 (Black) and ground	0 ohms	
	Socket 7 and ground	more than 70,000 ohms	
	Socket 8 and ground	more than 70,000 ohms	
	Socket 3 (Red) and coil tower	7,000 to 13,000 ohms	Replace coil
	Socket 5 (Green) and Socket 4 (Blue)	1.0 to 2.0 ohms	
	Socket 5 (Green) and ground	more than 4.0 ohms	Check for short at coil DEC terminal or in wiring to DEC terminal
	Socket 3 (Red) and Socket 4 (Blue)	1.0 to 2.0 ohms	Replace resistance wire

1975

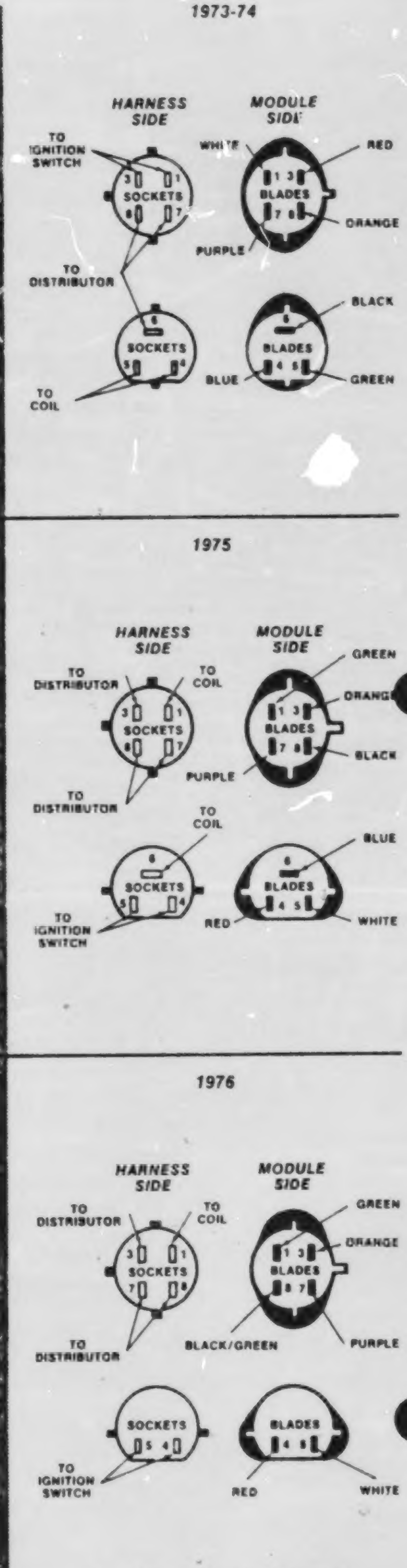
	Test Voltage Between	Should Be	If Not
Key On	Coil BAT terminal and ground (Module connected, DEC terminal grounded)	4.9 to 7.9 volts	Low reading - Check primary wiring High reading - Replace resistance wire
	Socket 4 (Red) and ground	Battery voltage ± 0.1 volt	Repair red wire, check connectors
	Socket 1 (Green) and ground	Battery voltage ± 0.1 volt	Check green wire to coil, check coil
Cranking	Socket 5 (White) and ground	8 to 12 volts	Repair white wire, check connectors
	Socket 6 (Blue) and ground (Jumper socket 1 to 8)	more than 6 volts	Check coil connections, check bypass circuit
	Socket 3 (Orange) and Socket 7 (Purple)	0.5 volt ac or any dc voltage	Replace magnetic pickup (stator)
	Test Resistance Between	**Should Be**	**If Not**
Key Off	Socket 3 (Orange) and Socket 7 (Purple)	400 to 800 ohms	Replace magnetic pickup (stator) or repair ground connection
	Socket 8 (Black) and ground	0 ohms	
	Socket 3 and ground	more than 70,000 ohms	
	Socket 7 and ground	more than 70,000 ohms	
	Socket 4 (Red) and coil tower	7,000 to 13,000 ohms	Replace coil
	Socket 1 (Green) and Socket 6 (Blue)	1.0 to 2.0 ohms	
	Socket 1 (Green) and ground	more than 4.0 ohms	Check for short at coil DEC terminal or in wiring to DEC terminal
	Socket 4 (Red) and Socket 6 (Blue)	1.0 to 2.0 ohms	Replace resistance wire

1976

	Test Voltage Between	Should Be	If Not
Key On	Coil BAT terminal and ground (Module connected DEC terminal grounded)	4.9 to 7.9 volts	Low reading - Check primary wiring High reading - Replace resistance wire
	Socket 4 (Red) and ground	Battery voltage ± 0.1 volt	Repair red wire, check connectors
	Socket 1 (Green) and ground	Battery voltage ± 0.1 volt	Check green wire to coil, check coil
Cranking	Socket 5 (White) and ground	8 to 12 volts	Repair white wire, check connectors
	Socket 3 (Orange) and Socket 7 (Purple)	0.5 volt ac or any dc voltage	Replace magnetic pickup (stator)
	Test Resistance Between	**Should Be**	**If Not**
Key Off	Socket 3 (Orange) and Socket 7 (Purple)	400 to 800 ohms	Replace magnetic pickup (stator) or repair ground connection
	Socket 8 (Black) and ground	0 ohms	
	Socket 3 and ground	more than 70,000 ohms	
	Socket 7 and ground	more than 70,000 ohms	
	Socket 4 (Red) and coil tower	7,000 to 13,000 ohms	Replace coil
	Coil BAT and DEC terminal	1.0 to 2.0 ohms	
	Socket 1 (Green) and Socket 4 (Red)	3.0 to 4.0 ohms	Check for short at coil DEC terminal or in wiring to DEC terminal
	Socket 4 (Red) and coil BAT terminal	1.0 to 2.0 ohms	Replace resistance wire


1973-74
IGNITION SWITCH
S
R
RESISTOR
DISTRIBUTOR
DISTRIBUTOR CONNECTOR
PURPLE
BLACK
ORANGE
IGNITION COIL
BAT
DEC
+
−
WHITE
RED
ORANGE
PURPLE
MODULE
Wire sequence has been arranged to simplify schematic.
BLUE
BLACK
GREEN
1975
IGNITION SWITCH
S
R
S
RESISTOR
SOCKETS
BLADES
RED
BLUE
WHITE
BAT
IGNITION COIL
DEC
MODULE
Wire sequence has been arranged to simplify schematic.
DISTRIBUTOR
DISTRIBUTOR CONNECTOR
ORANGE
BLACK
PURPLE
GREEN
ORANGE
BLACK
PURPLE
1976
MODULE
IGNITION SWITCH
S
R
S
RESISTOR
SOCKETS
BLADES
RED
WHITE
BAT
IGNITION COIL
DEC
Wire sequence has been arranged to simplify schematic.
MODULE
DISTRIBUTOR
DISTRIBUTOR CONNECTOR
ORANGE
BLACK
PURPLE
GREEN
ORANGE
PURPLE
BLACK/GREEN

Primary Circuit Diagrams of Ford Solid-State Ignitions


1973-74
HARNESS SIDE
MODULE SIDE
TO IGNITION SWITCH
SOCKETS
WHITE
RED
BLADES
ORANGE
PURPLE
TO DISTRIBUTOR
BLACK
SOCKETS
BLADES
BLUE
GREEN
TO COIL
1975
HARNESS SIDE
MODULE SIDE
TO DISTRIBUTOR
TO COIL
GREEN
ORANGE
SOCKETS
BLADES
BLACK
PURPLE
TO DISTRIBUTOR
TO COIL
BLUE
SOCKETS
BLADES
TO IGNITION SWITCH
RED
WHITE
1976
HARNESS SIDE
MODULE SIDE
TO DISTRIBUTOR
TO COIL
GREEN
ORANGE
SOCKETS
BLADES
TO DISTRIBUTOR
BLACK/GREEN
PURPLE
SOCKETS
BLADES
TO IGNITION SWITCH
RED
WHITE

Ford Connector Identification

Troubleshooting the Delco HEI System

Basic tests of the HEI system are made with a voltmeter and an ohmmeter to isolate circuit problems.

Before making any circuit checks with test meters, be sure that all primary circuit connectors are properly installed and that spark plug cables are secure at the distributor and at the plugs.

Be sure that the four distributor cap latches are secure and that the coil and coil cover screws are tight on V-6 and V-8 units. If all connections are secure but the engine will not start, make the following tests:

1. Connect the negative lead of your voltmeter to ground and the positive lead to the BAT terminal on the HEI distributor.
2. Turn on the ignition switch.
3. If the voltage is zero, the circuit is open between the battery and the distributor and must be repaired.
4. If the voltmeter indicates approximately battery voltage, hold one spark plug lead with insulated pliers about 1/4 inch from a clean area on the block and crank the engine.
5. If sparking occurs, the trouble is not in the ignition system. Check the spark plugs and fuel system.
6. If sparking does not occur, the ignition coil and the pickup coil must be checked. These tests may be made with the distributor in or out of the engine.

The older Delco Unitized ignition system, used on some 1971-74 Pontiacs, can be checked using procedures similar to those used on the HEI system.

Ignition Coil Test

1. Remove the cap and coil from the V-6 and V-8 HEI distributor by releasing the four latches. Coils for inline 4- and 6-cylinder HEI systems are mounted separately from the distributor.

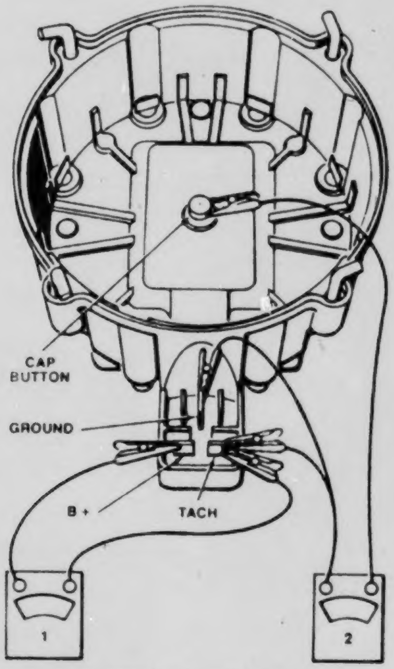
2. Inspect the cap, coil and rotor for signs of crossfiring or leakage.

3. Make tests with an ohmmeter as shown for each system:

V-6 and V-8 HEI Systems

a. Test point 1 should show continuity (0 to 1 ohm resistance). If not, replace the coil.

b. Test point 2 measures the resistance of the coil secondary winding. On coils made before May 1975, measure between the cap button and the TACH terminal. On coils made after May 1975, measure between the cap button and the GROUND terminal. Check the car maker's specifications

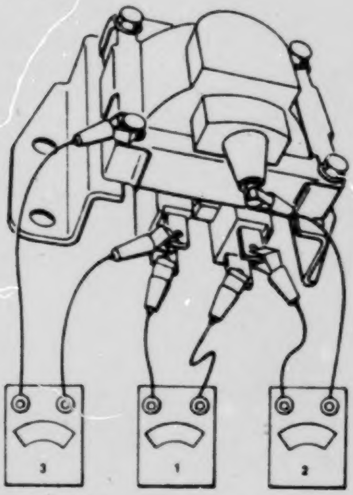


HEI V-8 and V-6 Coil Test Points

for resistance values. If resistance is out of limits, replace the coil. A high reading indicates an open; a low reading indicates a short.

Inline 4- and 6-cylinder HEI Systems

a. Test point 1 should show continuity (0 to 1ohm resistance). If not, replace the coil.



HEI 4- and 6-Cylinder
Coil Test Points

b. Test point 2 measures the resistance of the coil secondary winding. Check the car maker's specifications for resistance values. If resistance is out of limits, replace the coil. A high reading indicates an open; a low reading indicates a short.

c. Test point 3 should show infinite resistance. If resistance is less than infinite, replace the coil.

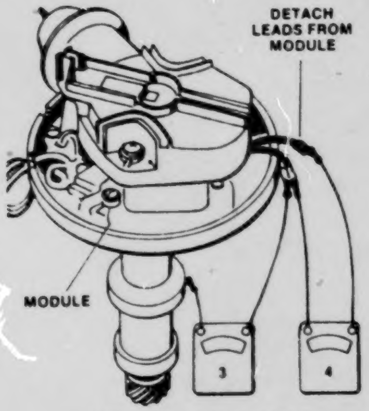
Pickup Coil Test

1. Connect a vacuum source to the vacuum advance unit and check vacuum advance operation. If the vacuum unit is inoperative, replace it.

2. Remove the two pickup coil leads from the control module.

3. Connect an ohmmeter to test point 3 and operate the vacuum advance mechanism through its full range.

4. Resistance between either pickup coil lead and the distributor housing must be infinite. If not, replace the pickup coil.



HEI System Pickup Coil Test Points

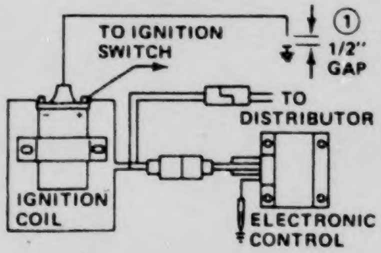
5. Connect an ohmmeter to test point 4 and operate the vacuum advance mechanism through its full range.

6. Check the car maker's specifications for pickup coil resistance values. If resistance is out of limits, replace the pickup coil. If no defects are found in the ignition coil or the pickup coil but the ignition still will not operate, the fault is probably in the electronic control module. Install a new module and retest the system.

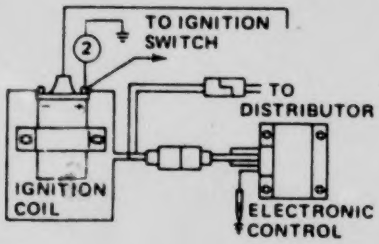
Troubleshooting The AMC-Prestolite Electronic Ignition System

AMC and Presolite recommend a simple 6-step troubleshooting sequence to check out an inoperative ignition system on the car. The checks require only a 12-volt test light (No. 57 bulb) and an ohmmeter. Turn the ignition switch on and proceed as follows:

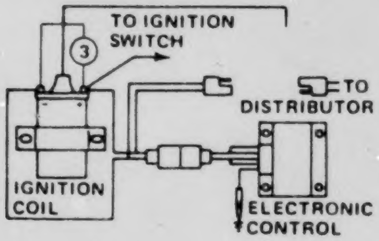
1. To be sure the fault is in the ignition,remove the coil wire from the distributor cap and hold it ½ inch from a good ground. Crank the engine and watch for steady sparking from the coil wire. If sparks occur, the ignition is OK, and the problem is elsewhere in the engine.


TO IGNITION SWITCH
①
1/2" GAP
TO DISTRIBUTOR
IGNITION COIL
ELECTRONIC CONTROL

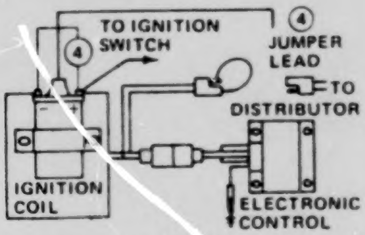
2. If no sparks occur connect the test light from the coil + terminal to ground. Turn the ignition switch to both ON and START. The bulb should light in both positions. If it does not, the fault is in the circuit between the battery and coil.


TO IGNITION SWITCH
②
TO DISTRIBUTOR
IGNITION COIL
ELECTRONIC CONTROL

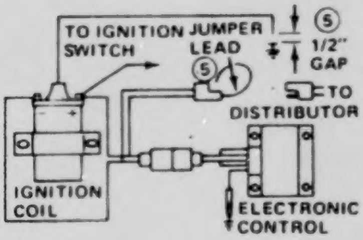
3. If the bulb lights in both positions, connect the test light across the coil + and - terminals. Unplug the sensor leads near the distributor and turn the ignition on. If the bulb does not light, check the control unit ground connection. If the ground is OK, the control unit is defective and must be replaced.


TO IGNITION SWITCH
③
TO DISTRIBUTOR
IGNITION COIL
ELECTRONIC CONTROL

4. If the bulb lights in step 3, short across the terminals in the sensor lead coming from the control unit. If the bulb does not go off, the fault is in the control unit.



5. If the bulb does go off in step 4, remove the test light and reestablish the ½ -inch gap from the coil wire to ground. Short across the terminals of the sensor lead as in step 4. If a spark does not occur each time the terminals are shorted the coil is faulty.



6. If a spark occurs whenever the terminals are shorted, the fault is in the sensor or the control unit. Connect an ohmmeter to the sensor leads at the distributor. Resistance should be 1.6 to 2.0 ohms. Tap the sensor lightly with a pencil; resistance should not vary. Disconnect one ohmmeter lead from the sensor lead and touch it to the center core of the sensor. The ohmmeter must show an open circuit. If the sensor passes these ohmmeter checks, the fault if probably in the control unit, and it should be replaced.

Measure the coil primary resistance between the coil positive and negative terminals. Measure the secondary resistance between the center tower and the positive terminal. Replace the coil if readings are not within specifications.

Connector terminals should be cleaned and lubricated with Vaseline petroleum jelly, or equivalent.

Solid-State Distributor Service

Because breaker points, a condenser, and a cam are not used in solid-state distributors, they do not require, the same amount of periodic service as breaker-point distributors. However, the centrifugal and vacuum advance mechanisms used on solid-state distributors should be tested periodically and cleaned or adjusted as necessary.

The air gap is Chrysler and IHC-Prestolite distributors is adjustable

Electrical Competencies - Ignition System

No. E -12 Testing Electronic Control Modules

Worksheet # 1

Name ______________________________ Date ____________ Grade ____________

Chrysler Electronic Ignition

1. Perform steps one through 5 in the information sheet on Chrysler Ignition.
2. Step 6, Cavity No. 1, voltage should be within 1 volt of battery voltage. Your reading is ______________ volt.
3. Step 7, Cavity No. 2, voltage should be within one volt of battery voltage. Your reading is ________________v.
4. Step 8, Cavity No. 3, voltage should be within one volt of battery voltage. Your reading is ________________v.
5. Step 9, Cavities No. 4 and No. 5, resistance should be between 150 and 900 ohms. Your resistance is ________________ohms.
6. Step 10, if resistance is higher or lower then specifications disconnect the dual-lead connector from the distributor and check the resistance through the pickup coil in the distributor.
7. Step 11, if the reading is still out of limits replace pickup coil.
8. Step 13, you should have continuity between pin No. 5 and ground. Continuity Yes ________ No __________
9. Step 14, 1/4 inch spark while cranking Yes __________ No__________
10. If spark does not occur, replace module and repeat the test.
11. If spark still does not occur, after replacing the module, replace the coil.

Instructor's Initials ________________

Electrical Competencies - Ignition System

No. E-12 Testing-Electronic Control Modules

Worksheet # 2

Name ______________________________ Date ______________ Grade __________

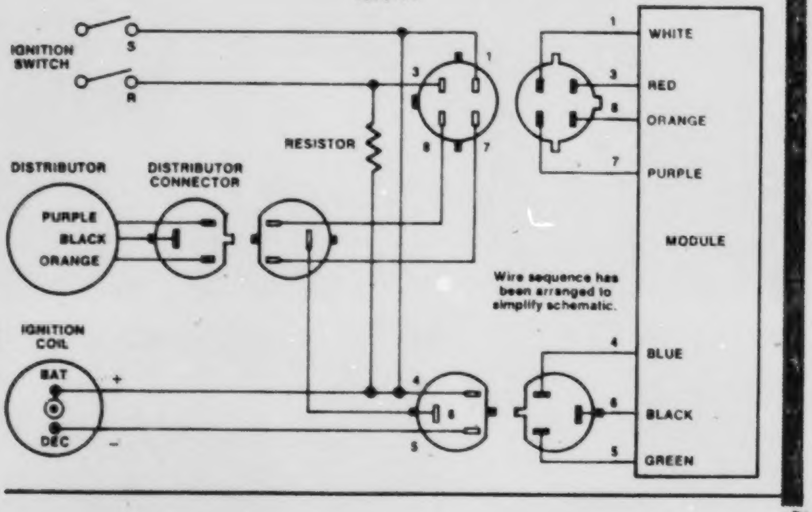
Ford Solid-State Ignition

1. Before testing the primary circuit read information sheet # 12 pertaining to the Ford system.
2. Disconnect both connectors at the module and connect the negative lead of your voltmeter to a good engine ground.
3. If your Ford vehicle is 1973 to 1976 use the following chart along with the information sheet.
4. If your Ford vehicle is a model year other than the ones mentioned above ask your instructor to obtain the appropriate specifications.

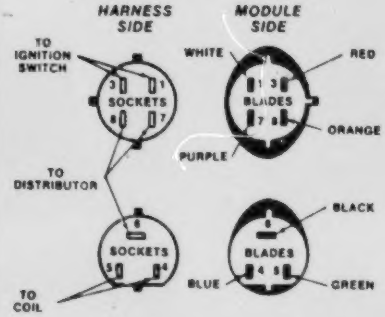
1973-74

	Test Voltage Between	Should Be	
Key On	Coil BAT terminal and ground (Module connected, DEC to terminal grounded)	4.9 to 7.9 volts	
	Socket 3 (Red) and ground	Battery voltage ± 0.1 volt	
	Socket 5 (Green) and ground	Battery voltage ± 0.1 volt	
Cranking	Socket 1 (White) and ground	8 to 12 volts	
	Socket 5 (Green) and ground	8 to 12 volts	
	Socket 7 (Purple) and Socket 8 (Orange)	0.5 volt ac or any dc voltage	
	Test Resistance Between	**Should Be**	
Key Off	Socket 7 (Purple) and Socket 8 (Orange)	400 to 800 ohms	
	Socket 6 (Black) and ground	0 ohms	
	Socket 7 and ground	more than 70,000 ohms	
	Socket 8 and ground	more than 70,000 ohms	
	Socket 3 (Red) and coil tower	7,000 to 13,000 ohms	
	Socket 5 (Green) and Socket 4 (Blue)	1.0 to 2.0 ohms	
	Socket 5 (Green) and ground	more than 4.0 ohms	
	Socket 3 (Red) and Socket 4 (Blue)	1.0 to 2.0 ohms	

1973-74


IGNITION SWITCH
S
R
RESISTOR
DISTRIBUTOR
DISTRIBUTOR CONNECTOR
PURPLE
BLACK
ORANGE
IGNITION COIL
BAT
DEC
+
-
1
3
8
7
4
6
5
WHITE
RED
ORANGE
PURPLE
MODULE
BLUE
BLACK
GREEN
Wire sequence has been arranged to simplify schematic.

1973-74


HARNESS SIDE
MODULE SIDE
TO IGNITION SWITCH
SOCKETS
3
1
8
7
TO DISTRIBUTOR
6
5
4
TO COIL
WHITE
RED
BLADES
ORANGE
PURPLE
BLACK
BLUE
GREEN

Instructor's Initials ____________

Electrical Competencies - Ignition System

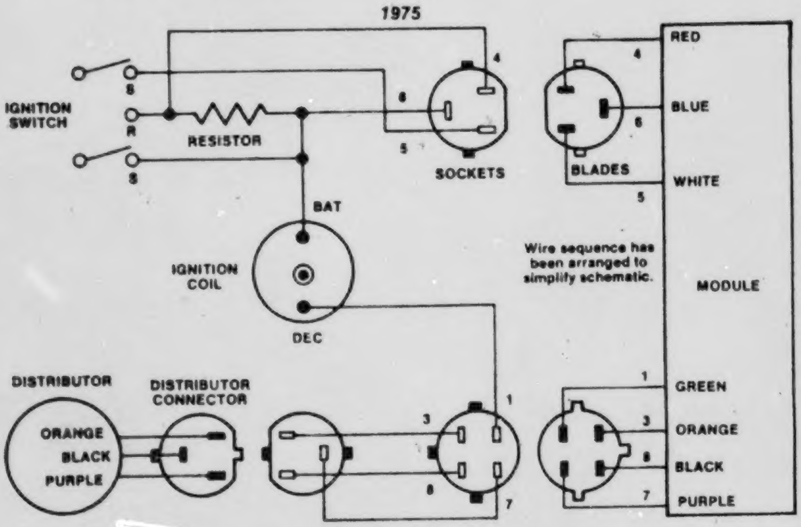
No. E-12 Testing Electronic Control Modules

Worksheet # 2
Page 2

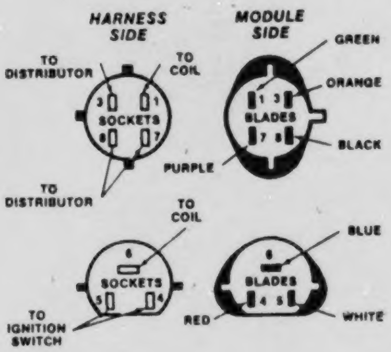
1975

	Test Voltage Between	Should Be	
Key On	Coil BAT terminal and ground (Module connected, DEC terminal grounded)	4.9 to 7.9 volts	
	Socket 4 (Red) and ground	Battery voltage ± 0.1 volt	
	Socket 1 (Green) and ground	Battery voltage ± 0.1 volt	
Crank-ing	Socket 5 (White) and ground	8 to 12 volts	
	Socket 6 (Blue) and ground (Jumper socket 1 to 8)	more than 6 volts	
	Socket 3 (Orange) and Socket 7 (Purple)	0.5 volt ac or any dc voltage	
	Test Resistance Between	**Should Be**	
Key Off	Socket 3 (Orange) and Socket 7 (Purple)	400 to 800 ohms	
	Socket 8 (Black) and ground	0 ohms	
	Socket 3 and ground	more than 70,000 ohms	
	Socket 7 and ground	more than 70,000 ohms	
	Socket 4 (Red) and coil tower	7,000 to 13,000 ohms	
	Socket 1 (Green) and Socket 6 (Blue)	1.0 to 2.0 ohms	
	Socket 1 (Green) and ground	more than 4.0 ohms	
	Socket 4 (Red) and Socket 6 (Blue)	1.0 to 2.0 ohms	

1975


IGNITION SWITCH
S
R
S
RESISTOR
4
6
5
SOCKETS
4
6
5
BLADES
RED
BLUE
WHITE
BAT
IGNITION COIL
DEC
Wire sequence has been arranged to simplify schematic.
MODULE
DISTRIBUTOR
DISTRIBUTOR CONNECTOR
ORANGE
BLACK
PURPLE
3
1
8
7
1
3
8
7
GREEN
ORANGE
BLACK
PURPLE

1975


HARNESS SIDE
MODULE SIDE
TO DISTRIBUTOR
TO COIL
3
1
SOCKETS
8
7
TO DISTRIBUTOR
GREEN
ORANGE
1
3
BLADES
7
8
BLACK
PURPLE
TO COIL
6
SOCKETS
5
4
TO IGNITION SWITCH
BLUE
6
BLADES
4
5
RED
WHITE

Instructor's Initials ________________

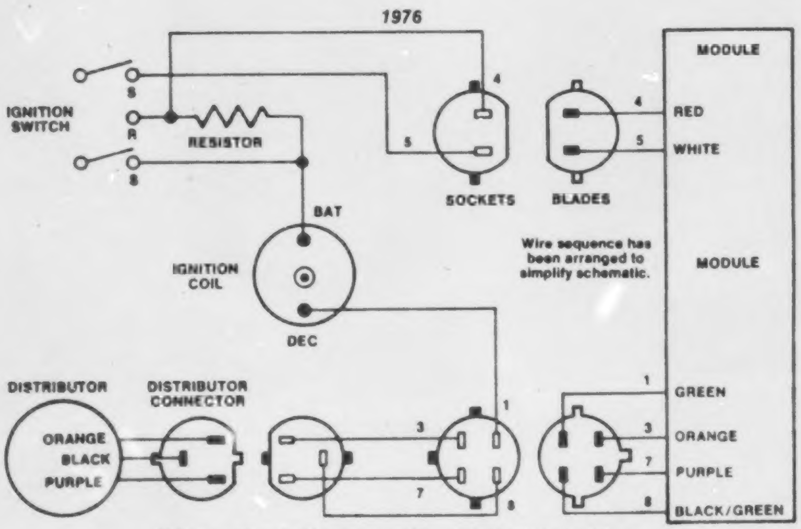
Electrical Competencies - Ignition System

No. E-12 Testing Electronic Control Modules

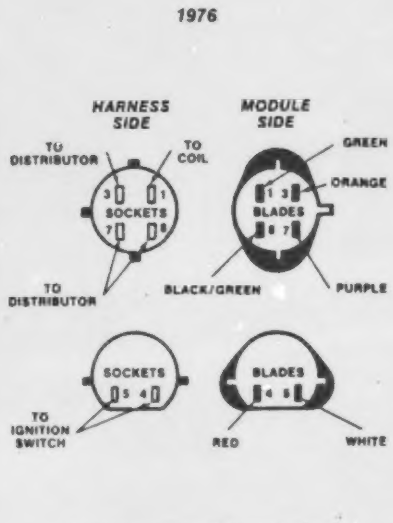
Worksheet # 2
Page 3

1976

	Test Voltage Between	Should Be	
Key On	Coil BAT terminal and ground (Module connected DEC terminal grounded)	4.9 to 7.9 volts	
	Socket 4 (Red) and ground	Battery voltage ± 0.1 volt	
	Socket 1 (Green) and ground	Battery voltage ± 0.1 volt	
Cranking	Socket 5 (White) and ground	8 to 12 volts	
	Socket 3 (Orange) and Socket 7 (Purple)	0.5 volt ac or any dc voltage	
	Test Resistance Between	**Should Be**	
Key Off	Socket 3 (Orange) and Socket 7 (Purple)	400 to 800 ohms	
	Socket 8 (Black) and ground	0 ohms	
	Socket 3 and ground	more than 70,000 ohms	
	Socket 7 and ground	more than 70,000 ohms	
	Socket 4 (Red) and coil tower	7,000 to 13,000 ohms	
	Coil BAT and DEC terminal	1.0 to 2.0 ohms	
	Socket 1 (Green) and Socket 4 (Red)	3.0 to 4.0 ohms	
	Socket 4 (Red) and coil BAT terminal	1.0 to 2.0 ohms	


1976
IGNITION SWITCH
S
R
S
RESISTOR
4
5
SOCKETS
BLADES
4
5
MODULE
RED
WHITE
BAT
IGNITION COIL
DEC
Wire sequence has been arranged to simplify schematic.
MODULE
DISTRIBUTOR
ORANGE
BLACK
PURPLE
DISTRIBUTOR CONNECTOR
3
7
1
8
1
3
7
8
GREEN
ORANGE
PURPLE
BLACK/GREEN

Primary Circuit Diagrams of Ford Solid-State Ignitions


1976
HARNESS SIDE
MODULE SIDE
TO DISTRIBUTOR
TO COIL
SOCKETS
3
1
7
8
TO DISTRIBUTOR
GREEN
ORANGE
BLADES
1
3
8
7
BLACK/GREEN
PURPLE
SOCKETS
5
4
TO IGNITION SWITCH
BLADES
4
5
RED
WHITE

Ford Connector Identification

Instructor's Initials_________________

Electrical Competencies - Ignition System

No. E -12 Testing Electronic Control Modules

Worksheet # 3

Name ______________________________ Date ______________ Grade __________

Delco HEI System

1. Read information sheet # 12 on Delco HEI System and perform the six steps under troubleshooting the Delco HEI System.

2. Ignition Coil Test -- V-6 and V-8

   Test point No. 1 Specs. 0-1 ohm Vehicle ______________

   Test point No. 2 Specs. __________ Vehicle ______________

3. Ignition Coil Test 4cyl. and 6cyl.

   Test point No. 1 Specs 0-1 ohm Vehicle ______________

   Test point No. 2 Specs. __________ Vehicle ______________

   Test point No. 3 Specs. __________ Vehicle ______________

4. Pickup Coil Test - follow information sheet.

   Test point No. 3 Specs. 0 ohms Vehicle ______________

   Test point No. 4 Specs. __________ Vehicle ______________

Instructor's Initials ______________

Electrical Competencies - Ignition System

No. E-12 Testing - Electronic Control Modules

Worksheet # 4

Name______________________________________Date____________Grade__________

AMC-PRESTOLITE ELECTRONIC IGNITION SYSTEM

1. Use the information sheet on AMC-Prestolite electronic ignition along with this worksheet.

2. Perform step one on information sheet.

3. Step two.
   Ignition switch ON Test light ON________ OFF______

   Ignition switch START Test light ON________ OFF______

4. Step three, information sheet
   Ignition switch ON Test light ON________ OFF______

5. Step four.
   If the bulb lights in step three, short across the terminals in the sensor lead coming from the control unit. Test light should go off. If the light does not go off the fault is in the control unit.

   Test light ON________ Test light OFF ________

   Short across the terminals of the sensor lead as in step four. If a spark does not occur each time the terminals are shorted, the coil is faulty.

   Spark ______________ No spark ____________

7. Step six.
   If a spark occurs when ever the terminals are shorted, the fault is in the sensor or the control unit.

   Connect an ohmmeter to the sensor leads at the distributor. Resistance should be 1.6 to 2.0 ohms. Sensor ______________ohms

   Disconnect one ohmmeter lead from the sensor lead and touch it to the center core of the sensor. The ohmmeter must show an open circuit.

   If the sensor passes these ohmmeter checks, the fault is probably in the control unit and it should be replaced.

   Coil Tests
   Measure the coil primary resistance between the coil positive and negative terminals. Specs.____________ Coil____________

   Measure the secondary resistance between the center tower and positive terminals. Specs.____________ Coil ____________

   Replace coil if the readings are not within specifications.

Instructor's Initials__________

AUTO MECHANICS

Electrical Competencies

No. E-13 Ignition System Adjustments

OBJECTIVE: After completion of this unit, the student will be able to accurately make all the necessary adjustments in the ignition systems.

EXPLANATION: In order for a vehicle to obtain maximum performance and economy it is essential that the ignition system by properly adjusted.

MATERIALS NEEDED: Automobile

TOOLS NEEDED: Hand tools
Dwell meter
Timing light
Flat feeler gauge
Wire feeler gauge

References	Do
#1. p.21-11to 33	1. Read assigned references.
#2. p. 56,62-63, 67-69	2. Read information sheets # 1.
#3. p.508,526, 502-503	3. Do worksheet # 1 and # 2.
#4. p.404-408,415-416,411-412	4. Read information sheet # 2.
	5. Do worksheet #3 and # 4.
#5. p.217-226	6. Read information Sheet # 3.
#6. p. 314-316	7. Do worksheet # 5
#7. p.342-343, 362-366	8. Read information sheet # 4
#8. --	9. Do worksheet # 6
	10. Do worksheet # 7

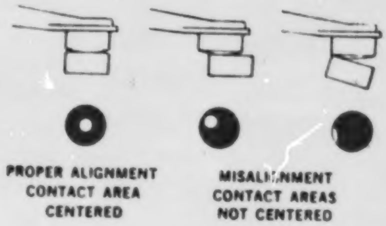
Electrical Competencies - Ignition System

No.E-13 Ignition System Adjustments

Information Sheet # 1

BREAKER POINT INSTALLATION - ALIGNMENT & SPRING TENSION

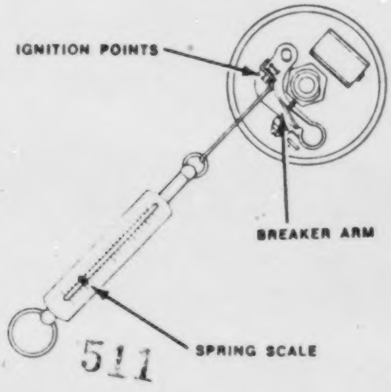
Correct ignition point alignment and spring tension are essential for proper ignition operation and long service life. Points are correctly aligned when the mating surfaces are in the center of both contacts, the faces are parellel, and the diameters are concentric. This ensures maximum contact area and precise switching action by points.

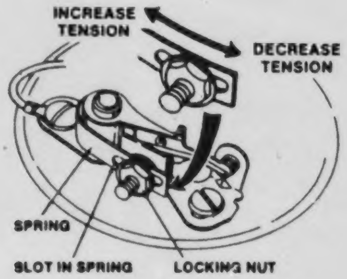


Correct spring tension also ensures precise point action. Excessive spring tension causes rapid cam and rubbing block wear and, in some cases, distributor bushing wear. If spring tension is too light, the points will bounce as they open and close at high speed. This generally results in a loss of engine power.

Replacement ignition points for many distributors are available in preassembled sets in which the point alignment and spring tension have been set at the factory. Preassembled point sets generally do not require alignment, but should be checked and aligned if necessary when installed. Dwell adjustment is usually the only adjustment required for preassembled points.

Some replacement points that come as a two-piece set may need alignment and spring tension adjustment as well as the normal dwell adjustment. Spring tension can be measured with several types of spring scales made for this purpose. Consult the manufacturer's specifications for proper tension. Do not let the scale arm rub the distributor housing when checking spring tension. This will cause a false reading.

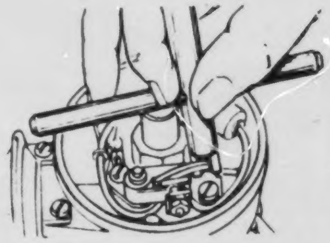



INCREASE TENSION
DECREASE TENSION
SPRING
SLOT IN SPRING
LOCKING NUT

Spring tension is generally adjusted by moving an elongated notch in the end of the spring back and forth on the spring retainer.

If required, point alignment may be adjusted with a special aligning tool.

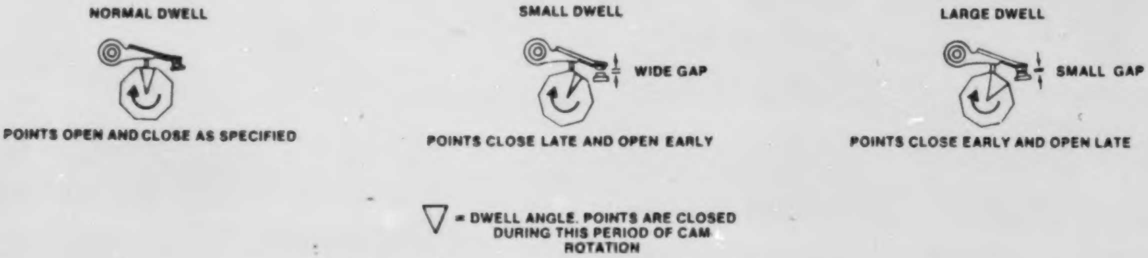
When making this adjustment, never bend the movable contact arm. Bend the startionary contact support to correct the alignment.



DWELL ADJUSTMENT

The dwell angle of a breaker-point distributor is the number of degrees of distributor rotation during which the points stay closed. Dwell adjustment is one of the most important parts of distributor service.

Dwell is adjusted by changing the point gap. A smaller gap increases the dwell; a larger gap decreases the dwell. Dwell can be measured directly with a dwell meter, oscilloscope, or distributor tester and adjusted if necessary. It can also be adjusted by setting the point gap with a feeler gauge.


NORMAL DWELL
POINTS OPEN AND CLOSE AS SPECIFIED
SMALL DWELL
WIDE GAP
POINTS CLOSE LATE AND OPEN EARLY
LARGE DWELL
SMALL GAP
POINTS CLOSE EARLY AND OPEN LATE
▽ = DWELL ANGLE. POINTS ARE CLOSED DURING THIS PERIOD OF CAM ROTATION

New, properly aligned points can be set with reasonable accuracy using a feeler gauge. General procedures are given below. Used points must always be adjusted using a dwell meter, oscilloscope, or distributor tester.

A distributor tester (also called a synchroscope or synchrograph) not only provides the capability for precise dwell adjustment, it can be used to test and adjust centrifugal and vacuum advance mechanismes, measure dwell variation, and check for shaft and bushing wear with great accuracy. When using a distributor tester, mount the distributor in the test machine and perform all tests according to the equipment maker's instructions.

General procedures for adjusting dwell using a dwell meter or oscilloscope with the distributor in the engine are given below. Additional information on oscilloscope testing is given later in this chapter.

Dwell Adjustment - Solid Cap. Single Points

1. Remove the coil high-tension lead from the distributor cap and ground it.

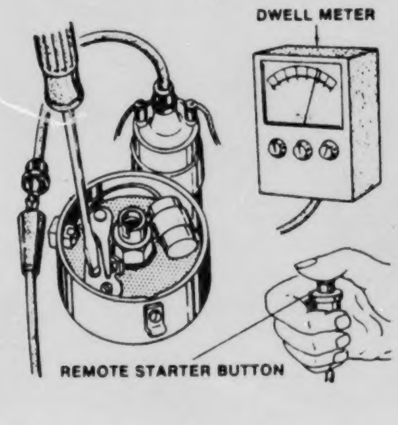
2. Remove the cap and rotor.

3. Check the car maker's instructions on disconnecting vacuum advance and retard lines. Disconnect and plug vacuum lines if required. Disconnect Chrysler distributor solenoids.

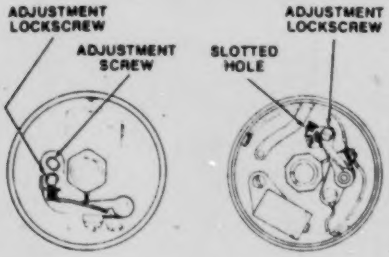
4. Connect a remote starter switch to the starting system.

5. Connect the dwell meter or oscilloscope to the engine according to the manufacturer's instructions.

6. Turn the ignition on and loosen the breaker point lockscrew.



7. While observing the dwell meter, crank the engine and adjust the points to the specified dwell angle. Some points are adjusted by turning an eccentric adjustment screw; others are adjusted by moving the mounting bracket with a screwdriver placed in a slotted hole.


ADJUSTMENT LOCKSCREW
ADJUSTMENT SCREW
SLOTTED HOLE
ADJUSTMENT LOCKSCREW

8. Tighten the point lockscrew and turn the ignition off.

9. Wipe the cam with a clean cloth and apply a thin film of cam lubricant. If a cam lubricator is used, turn it end for end to expose fresh lubricant to the cam, or replace the lubricator. Do not try to add oil to a lubricator.

10. Reinstall the rotor and cap and reconnect the coil high-tension lead.

11. Start and idle the engine and recheck the dwell setting. Readjust if required.

12. Check and adjust the timing.

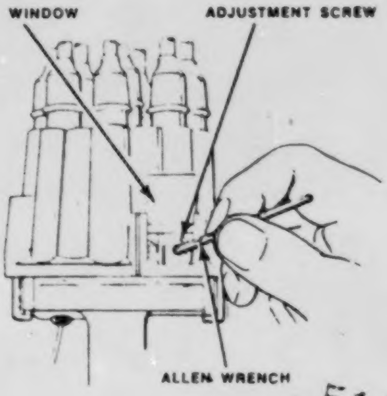
Dwell Adjustment-- Delco-Remy External Adjustment

Delco-Remy V-6 and V-8 breaker-point distributors have windows in the caps so that the dwell angle can be set with the cap in place and the engine running at idle.

1. Connect the dwell meter or oscilloscope to the ignition.

2. Start and idle the engine.

3. Raise the window in the distributor cap and insert a hex (allen) wrench into the point adjustment screw.


WINDOW
ADJUSTMENT SCREW
ALLEN WRENCH

4. While observing the dwell meter, turn the screw clockwise to increase the dwell. counterclockwise to decrease it. The adjustment is self-locking.

5. Remove the wrench and close the cap window.

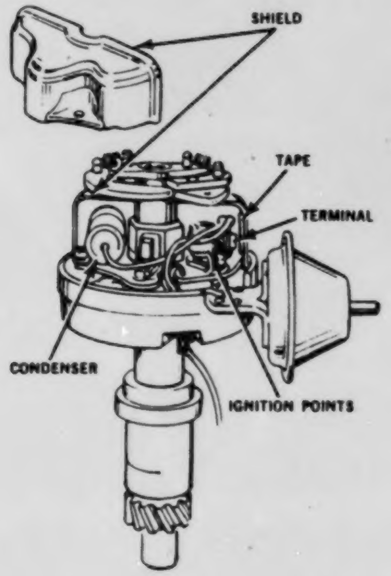
6. Check and adjust the timing.

Radiofrequency Interference (RFI) Shield

On its 1970-73 models, General Motors uses an RFI shield in the distrubutor of all its V-8 engines. The RFI shield prevents interference signals from being picked up by the windshield radio antenna.

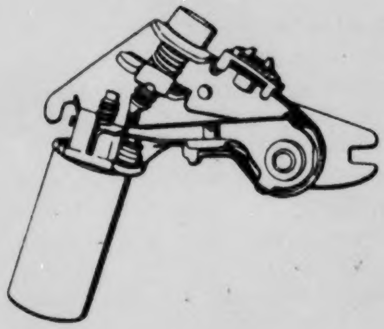
It is important that sufficient space exists between the ignition point connector and the inside of the shield after installing new points. A piece of insulating tape is pasted inside the cover in the connector area as insurance against accidental short circuiting of the ignition primary circuit. When installing a new condenser, position it so that the condenser lead end is flush with its mounting bracket to take the slack out of the lead. Then tighten the bracket holddown.

The two halves of the shield and the distributor rotor must be removed when servicing or replacing the ignition points. The halves of the shield are not interchangeable so they cannot be improperly installed. Be sure the primary or condenser leads are not caught under the edge of the shield before tightening the two shield retaining screws.



Failure to reinstall the shield will result in radio interference.

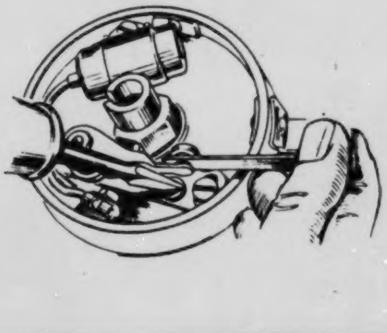
Beginning in 1974, General Motors breaker-point distributors for V-8 engines use a one-piece assembly of points and condenser called a Uniset. Distributors with the Uniset points and condenser do not have an RFI shield because the one-piece Uniset construction eliminates radio interference signals.



The Uniset assembly may be installed in pre-1974 distributors with no modifications. When this is done, the RFI shield can be discarded. It is also possible to install conventional points and a separate condenser in a distributor originally equipped with a Uniset. This can usually be done with no modifications; however, in some cases it is necessary to drill and tap a condenser mounting hole in the breaker plate. If conventional points and condenser are installed in place of a Uniset, an RFI shield must also be installed.

Point Gap Adjustment With Feeler Gauge

If a dwell meter is not available for a dwell adjustment, new breaker points can be set with a feeler gauge. This is easier with the distributor out of the engine, but it can be done with the distributor installed. Connect a remote cranking switch and crank the engine in short bumps until the breaker point rubbing block is exactly on a high point of the cam. Slide a clean feeler gauge between the points and adjust the gap by shifting the stationary point arm. A slight drag should be felt as the gauge is drawn between the points and there should be no perceptible point movement. Tighten the hold-down screw and recheck the gap. Lubricate the cam. Check and adjust the ignition timing.



Dwell Angle Variation Test

Two dwell angle variation measurements are important for thorough tune-up service. A dwell meter can be used to measure the average dwell of all cylinders. A distributor tester or an oscilloscope can be used to measure the average dwell and the individual dwell for each cylinder.

Most manufacturers allow a small amount of average dwell variation as engine speed changes. The allowable dwell variation ranges from a little as 2 degrees to as much as 8 degrees, depending on the type of distributor. Generally, the allowable variation is less for center-pivot breaker plates (Delco) than it is for side-pivot breaker plates (Chrysler, Autolite, Motorcraft). Consult the car maker's specifications for allowable average variation and the engine or distributor speed at which it should be checked.

Check the dwell variation among cylinders with an oscilloscope or distributor tester. The points-open and points-close signals should not vary from one cyclinder to another by more than 2 to 4 degrees. Excessive variation of the average or the individual dwell angles indicates electrical or mechanical defects in the distributor.

Among the most common causes of excessive dwell variation are:

Worn distributor shaft and bushing

Worn cam

Loose or worn breaker plate

Loose electrical connection at the points

Loose connections and loose breaker plates can be corrected with normal service. Severe mechanical defects, such as a worn cam or bushings, require distributor overhaul or replacement.

Electrical Competencies - Ignition System

No.E-13 Ignition System Adjustments

Information Sheet # 2

IGNITION TIMING ADJUSTMENT

Ignition timing can be adjusted statically, with the engine off, or dynamically, with the engine running. Static timing is set when a distributor is reinstalled in an engine. Final adjustment of the timing is usually made, using a stroboscopic timing light, with the engine running. A few car makers, however, provide only static timing specifications. Timing is usually set in relation to number-one cylinder, although some engines are timed to other cylinders.

Static Timing Adjustment

If rotor position is carefully marked before a distributor is removed and carefully observed when it is reinstalled, timing will generally be close enough for the engine to be started. Final adjustment can then be made using a timing light. If exact static timing is required, follow this procedure for a breaker-point system:

1. Bring the number-one piston to top dead center on the compression stroke and align the timing marks.

2. Install the distributor so that the rotor points exactly at the number-one spark plug terminal of the cap. Mark a reference line on the distributor body to align the rotor with the cap off.

3. Connect one lead to a test light to the coil distributor primary terminal and the other lead to ground.

4. Turn the ignition switch on. With the points open, the test light should come on.

5. Loosen the holddown bolt and rotate the distributor in the direction of rotor rotation until the light goes off. This indicates the points are closed.

6. Slowly rotate the distributor against rotor rotation until the light comes on. This indicates the points have just opened.

7. Tighten the holddown bolt.

Static timing can also be accomplished without a test light. Turn the ignition on with the points closed and slowly rotate the distributor against rotor rotation. A small arc will jump across the points when they open.

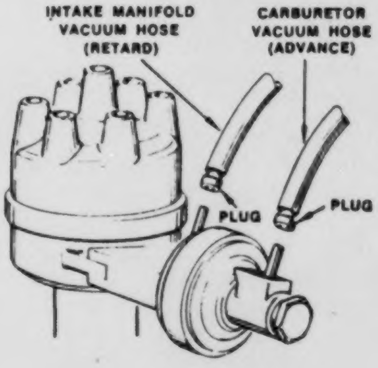
THE IGNITION SYSTEM - SERVICE

Dynamic Timing Adjustment

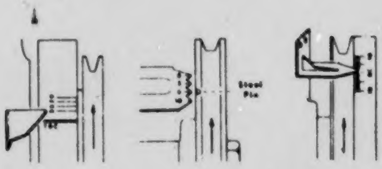
Dynamic timing is performed with a stroboscopic timing light triggered by voltage from the number-one spark plug. The light can be attached to an oscilloscope console or it can be a separate piece of equipment.

Prepare for timing adjustment by connecting the timing light to the number-one spark plug, either at the plug or at the distributor cap. Install an adapter at the plug or cap if necessary to connect the light. Never puncture a spark plug cable or boot with a sharp probe to connect a timing light. Many late-model timing lights have inductive pickups that clamp around the plug cable.

Dwell must be adjusted and the engine must be at its normal operating temperature before timing is adjusted. Check the car maker's instructions about disconnecting distributor vacuum lines. The timing is set on most engines with the distributor vacuum lines disconnected and plugged. However, some Manufacturers specify that the vacuum advance line be connected. On dual-diaphragm distributors, the manifold vacuum line that provides spark retard must be disconnected and plugged. Note the position of vacuum lines before disconnection so that they can be reinstalled correctly.



If the thermostatically controlled air cleaner is removed, plug the air cleaner vacuum line. It is not necessary to disconnect Chrysler distributor solenoids. Engines with retard solenoids must be running at slow idle so that the idle adjusting screw contacts the carburetor solenoid and energizes the distributor solenoid to retard the timing.

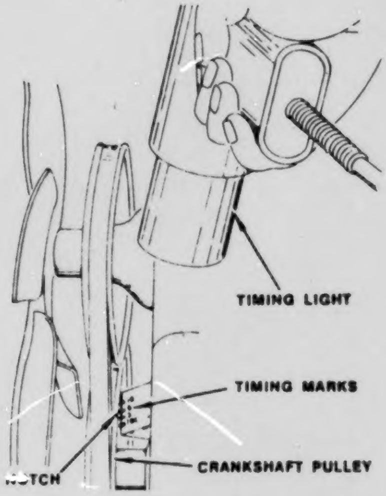


Locate the timing marks on the engine and crankshaft pulley or balancer, wipe them clean, and mark them with chalk or paint if necessary. Check the tune-up specifications for the exact timing setting and engine speed. On late-model engines, the timing setting is given on the engine tune-up date decal. This is the specification that should be followed. Adjust the timing as follows:

1. Connect a timing light and a tachometer to the engine.

2. Start the engine and run it at the specified speed.

3. Aim the flashing timing light at the timing marks and observe their position.



4. If adjustment is required, loosen the distributor holddown bolt and rotate the distributor against rotor rotation to advance the timing; with rotor rotation to retard the timing.

5. After timing adjustment, reconnect all vacuum lines and readjust the idle speed if necessary.

TIMING ADVANCE AND RETARD TESTS

Centrifugal advance and vacuum advance and retard mechanisms can be checked with the distributor installed in a distributor tester or in the engine. Specifications (called "advance curves") for degrees of advance or retard at varying speeds are essential. Whether the distributor is checked in a tester or in the engine, keep these principles in mind:

> Specifications given in distributor degrees and distributor rpm must be multiplied by 2 when the distributor is tested in the engine.
>
> Specification given in engine degrees and rpm must be divided by 2 when the distributor is checked in a tester.
>
> The basic timing setting must be added or subtracted, as reqired, when the distributor is checked in the engine.

Follow the equipment maker's instructions when using a distributor tester. Timing advance and retard can be checked on the engine with the following general procedures.

Timing Advance Tests With A Power Timing Light

Basic timing and idle speed, as well as dwell on breaker-point distributors must be adjusted before checking spark advance. A tachometer and a power timing light with an advance meter are required.

1. Connect the tachometer and timing light. Start and idle the engine.

2. Accelerate the engine to 2500 rpm or to the speed specified for checking total advance.

3. While observing the timing marks, adjust the timing light advance meter control until the marks are aligned at their initial setting.

4. Read the degrees of total advance recorded on the meter and compare to the specifications.

Total advance is centrifugal advance plus vacuum advance. To check centrifual or vacuum advance individually, continue the procedure.

5. With the engine at idle, disconnect and plug the distributor vacuum lines.

6. Accelerate the engine to 2500 rpm or other specified speed.

7. While observing the timing marks, adjust the advance meter control to align the marks at their initial setting.

8. Read the degrees of advance and compare to specifications. This reading is centrifugal advance only.

9. Reconnect the vacuum advance line ot the distributor vacuum unit.

10. Again observe the timing marks and adjust the advance meter until they are aligned at their initial position.

11. Subtract the centrifugal advance reading of step 8 from the new reading. The result is the amount of vacuum advance.

Some post-1971 cars with spark timing control emission systems do not provide vacuum advance with the vehicle stationary and the transmission in neutral. To test such a car, the vehicle must either be raised on a hoist and operated in gear at specified speeds, or the vacuum control devices must be bypassed. Vacuum switches and valves can often be bypassed by connecting a hose directly from the carburetor spark port or from a manifold vacuum port to the distributor vacuum unit. Vacuum advance units can also be checked with a vacuum hand pump as descirbed later in this chapter.

If either the centrifugal or the vacuum advance, or both, is out of limits, the advance mechanism requires adjustment or replacement. If spark advance specifications are given at several rpm test points, check the advance at each point to ensure precise control of ignition timing.

Vacuum Retard Test

If the distributor being tested has a dual-diaphragm unit, check the vacuum retard as follows:

1. Disconnect and plug both vacuum hoses at the distributor.

2. Start and idle the engine.

3. While observing the timing marks with a timing light. connect the manifold vacuum hose to the inner (distributor side) vacuum chamber.

4. Timing should immediately retard from the initial setting. Check the amount of retard with the timing light advance meter.

5. If the degrees of vacuum retard do not meet specifications, replace the vacuum unit.

Timing Advance And Retard Tests Without A Power Timing Light

If your timing light does not have a timing advance meter, the general operation of the centrifugal and vacuum advance and vacuum retard mechanisms can be checked, but the exact degrees cannot be measured.

1. Connect a tachometer and timing light. Start and idle the engine.

2. Disconnect and plug the distributor vacuum lines.

3. Accelerate the engine to 2000 or 2500 rpm while observing the timing marks. The marks should advance smoothly and steadily, indicating that the centrifugal advance is working.

4. While holding the engine speed at 2000 or 2500 rpm, unplug and connect the vacuum advance line to the distributor.

5. The timing marks should advance an additional amount and engine speed should increase, indicating that the vacuum advance is working.

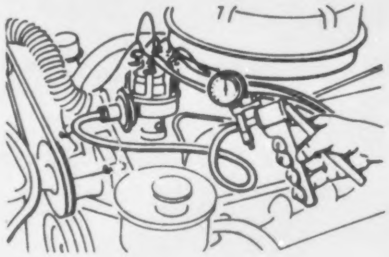
6. Check vacuum retard on dual-diaphragm distributors by connecting the manifold vacuum line to the retard chamber with the engine at idle. Timing should retard approximately 6 to 12 degrees, and engine speed should decrease.

Vacuum Advance Test With Vacuum Hand Pump

A hand operated vacuum pump can be used to test the precise vacuum advance curve of a distributor.

1. Disconnect and plug the vacuum line from the vacuum advance diaphragm and connect the tester hose to the advance unit. Use an adapter if required.

2. Close the pump release valve and operate the pump to apply 15 to 20 inches of vacuum.



3. Watch the gauge for at least 10 seconds. If the reading drops, the diaphragm is leaking.

4. Using a power timing light and advance meter, check the centrifugal spark advance at the specified rpm points. Leave the vacuum line to the advance unit disconnected and plugged.

5. Record the centrifugal advance at 1000 engine rpm or other engine speed specified for checking the vacuum advance unit.

6. With the engine speed at a steady 1000 rpm or other specified speed, apply vacuum to the advance diaphragm as listed in the car specifications. Usually four or five test points are given.

7. Record the advance at each point and subtract the reading from the centrifugal advance recorded in step 5. Compare the results with the vacuum advance specifications. If advance is out of limits, the vacuum unit must be repaired or replaced.

ADJUSTING DISTRIBUTOR ADVANCE MECHANISMS

The centrifugal and vacuum advance mechanisms for Ford Motor Company distributors can be adjusted according to the following precedures. Some Chrysler, Presolite, and Delco distributots can be adjusted by similar methods.

Adjustment is most easily made with the distributor mounted in a distributor tester. Many distributors can be adjusted, however, while in the engine by using an oscilloscope with a power timing light. Complete specifications for centrifugal and vacuum advance curves for the specific distributor (by part number) are essential. Advance ajustment should be performed by a skilled serviceman with the proper equipment.

Before adjusting the advance mechanisms, the distributor should be cleaned, inspected, and lubricated. Dwell on breaker-point distributors must be set before adjusting the advance mechanisms. Adjust centrifugal advance before vacuum advance.

Centrifugal Advance

1. Operate the distributor in the direction of rotation at the first rpm setting listed in the specifications.

2. Slowly increase speed to the rpm setting specified for the first advance reading.

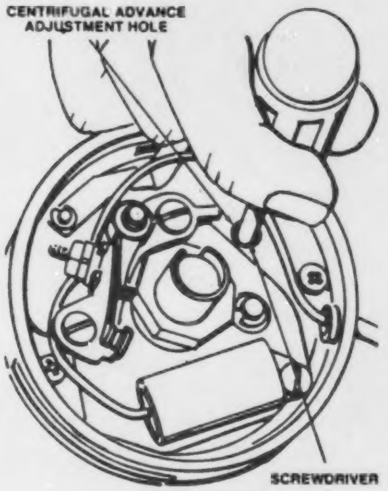
3. If advance is not correct, stop the distributor and bend one spring bracket to adjust spring tension. On Ford 2800xx V-6 distributors, remove a plug in the side of the body for access to the spring brackets. On all other distributors, adjust the bracket through a hole in the breaker plate or base plate.

4. Bend the bracket away from the distributor shaft to decrease advance (increase spring tension) or toward the shaft to increase advance (decrease tension. Mark the bracket for identification.

5. After adjusting one spring, check the minumum advance point again.

6. Operate the distributor at the specified rpm to give advance just below the maximum.

7. If maximum advance is not correct, stop the distributor and bend the other spring bracket to get the proper setting.



8. Check the advance at all rpm settings while operating the distributor up and down the rpm range.

Vacuum Advance

Vacuum advance units on most Ford distributors can be adjusted by two different methods, depending on design.

Autolite and Holley destributors used in 1971 and earlier vehicles are adjusted by changing calibration washer inside the vacuum advcance unit. This type of unit has a removable hex-head plug in the end of the housing. Autolite and Motorcraft distributors used in 1972 and later vehicles are adjusted by inserting an allen wrench through the vacuum hose nipple in the end of the housing and turning an internal nut.

On dual-diaphragm distributors, which provide both vacuum advance and retard, the retard diaphragm must be tested before adjusting the advance diaphragm. If the retard diaphragm is not working correctly, the advance diaphragm cannot be adjusted accurately. Retard diaphragms are not adjustable, and the entire vacuum unit must be replaced if it is bad.

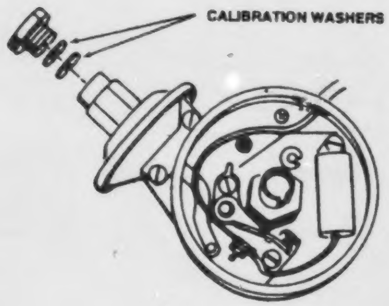
An independent vacuum source, either a hand pump or a distributor tester, is required in order to regulate the amount of vacuum applied during adjustment. Adjust the vaccum advance diaphragm as follow:

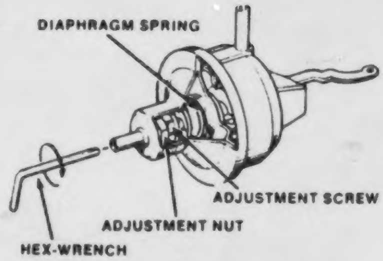
1. Connect the vacuum source to the fitting on the diaphragm and operate the distributor at the specified rpm.

2. Check the advance at the first vacuum setting given in the specifications.

3. If the advance is incorrect, adjust it as follows:

   a. On units calibration washers, remove the plug from the end of the housing. Add washers to decrease advance; remove washers to increase advance. Often, removing one washer and replacing it with another of a slightly different thickness will prodive a fine degree of adjustment.





   b. On units with an internal adjusting nut, insert a 1/8-inch allen wrench through the hose nipple. Turn the wrench clockwise to increase advance, counterclockwise to decrease it. Make adjustments in small increment and check advance after each change.

4. After advance is adjusted at one vacuum setting, check the advance points at other specified vacuum settings. Do not change the distributor speed from the original rpm setting while checking the vacuum advance points.

5. If the other vacuum advance points are not within limits there is leakage in the vacuum unit or line or a defective spring. Defective vacuum units must be replaced.

Information Sheet # 3

SPARK PLUG SERVICE

Spark plug service is an important part of a complete engine tune-up. Vehicle manufacturers' recommendations for plug-service intervals vary from as often as every 5,000 miles to as seldon as every 20,000 miles or more. Spark plug life depends onengine design, the kind of driving done, the type of fuel used,and the kinds of emission control devices employed. Generally, the plugs used in late-model, low-compression engines burning unleaded fuel will last longer than plugs in high-compression engines that require premium leaded fuel.

Follow the vehicle maker's recommendations for spark plug service intervals.

Spark Plug Removal

Follow this general procedure to remove spark plugs:

1. Remove the cables by grasping the plug boot and twisting gently while pulling. Do not pull on the cables.

2. Loosen each plug one or two turns with a spark plug socket.

3. Blow dirt away from the plugs with compressed air to keep it from falling into the cylinders when the plugs are removed.

4. Remove the plugs andplace each one in a tray by cylinder number for inspection.

5. On gasketed plugs, be sure the old gasket is removed with the plug. Chrysler sixes and hemispherical V-8's use gasket-type plugs installed in tubes without gaskets.

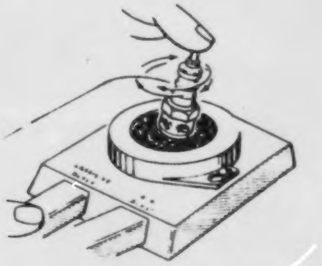
Spark Plug Cleaning

It is often more economical in terms of labor costs to install new spark plugs than to clean and regap old ones. However, used plugs that are not excessively worn can be cleaned for continued satisfactory use by following this procedure.

1. Wipe oil and grease from the outside of the plug with a clean cloth. Use a small amount of solvent if needed. Dry with compressed air.

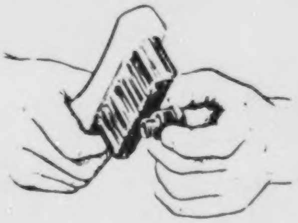
2. Carefully bend the ground electrode back with thin-nosed pliers to permit better abrasive cleaning.

3. Place the plug in an abrasive-blast machine and rotate plug slowly while sandblasting.

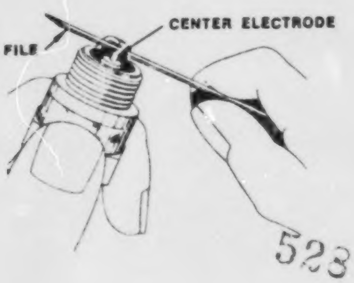


4. Use a compressed air blast to remove cleaning abrasive from the plug. Inspect the plug, particularly inside the shell, to be sure all deposits are removed.

5. Use a hand-held wire brush to clean the plug threads.



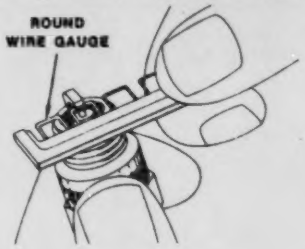
6. File the center electrode until it is flat and the inside surface of the ground electrode until a shiny surface appears.



Spark Plug Gapping

Both new and used spark plugs must be gapped to the engine manufacturer's specifications. Do not assume that new plugs are correctlv pregapped. Spark plugs used with many electronic ignition systems require wide gaps in the .060- to .080-inch range. Plug manufacturers supply special plugs for wide-gap applications. Wide-gap and narrow-gap plugs are made in identical heat ranges, the only difference being in the preset gap. Do not try to set a narrow-gap plug to wide-gap specifications, or vice versa. Electrode damage will result.

Use a round wire feeler gauge to measure the gap. A flat gauge will give an inaccurate reading. Bend only the ground electrode to adjust the gap. Use a plug-gapping tool and carefully bend the ground electrode to the required gap.



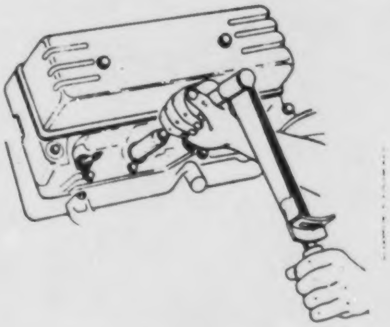
Spark Plug Installation

Install spark plugs as follow:

1. Wipe dirt and grease from the plug seats in the engine with a clean cloth.

2. Be sure the gaskets on gasketed plugs are in good condition and properly placed on the plugs.

3. Install the plugs into the engine finger tight. If the plugs cannot be installed easily be hand, the threads in the cylinder head may require cleaning with a thread-chasing tap. Be careful installing plugs or cleaning threads in aluminum heads.



4. Tighten the plugs with a torque wrench to the following foot-pound values:

	Iron Head	Aluminum Head
14 mm, gasketed	25-30	18-22
14 mm, tapered	7-15	7-15
18 mm, tapered	15-20	15-20

Information Sheet # 4

Chrysler Electronic Distributor Air Gap Adjustment

The air gap between the reluctor and pole piece is adjustable and must be set to minumum clearance when a new pickup unit is installed.

During service, the air gap does not change and requires no periodic adjustment.

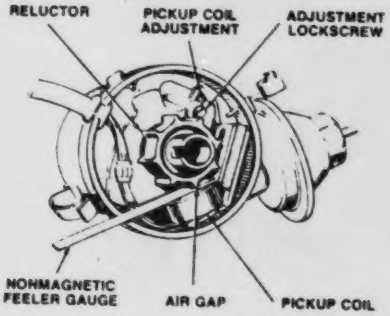
The air gap is adjusted similarly to breaker points.

A nonmagnetic feeler gauge must be used since a steel gauge will be attracted to the permanent magnet, making accurate gap setting impossible.

Check the air gap as follows:

CAUTION: Do not force the feeler gauges when checking the clearance.

1. Align a tooth on the reluctor with the pickup core.



2. An .008-inch feeler gauge should just slide between core. A .010-inch feeler should not enter the gap.

If air gap adjustment is required, proceed as follows:

1. Align one reluctor blade with pickup core.
2. Loosen the pickup coil adjustment lockscrew.
3. Place a .008-inch nonmagnetic feeler gauge between the reluctor blade and pickup core.
4. With screwdriver blace inserted in the adjustment slot, shift the distributor plate so the feeler gauge contacts the reluctor blade and pickup core.
5. Tighten the lockscrew. No force should be required to remove the feeler gauge. The adjustmanet can be checked by using a .010-inch feeler as a no-go gauge. Do not force a .010-inch gauge into the air gap.

Electrical Competencies - Ignition System

No. E-13 Ignition System Adjustments

Worksheet # 1

Name ______________________ Date ____________ Grade __________

TEST DWELL AND FEELER GAUGE AND DWELL METER

Year and Make ______________ ______________

Engine cylinders ____________ 4 ____________ 6 ____________ 8

Point Specifications

Dwell Angle ______________ Point Gap ______________

ADJUSTING DWELL WITH FEELER GAUGE

1. Remove distributor cap and rotor
2. Place breaker point rubbing block exactly on the high point of the cam.
3. Slide a clean feeler gauge, of the correct thickness, between the points and adjust the gap by shifting the stationary point arm.
4. Tighten the holddown screw and recheck gap.

Instructor's Initials __________

5. Replace distributor cap
6. Start engine -- check dwell with dwell meter. Check with instructor before removing dwell meter.

Instructor's Initials __________

Electrical Competencies - Ignition System

No.E-13 Ignition System Adjustments

Worksheet # 2

Name ______________________ Date __________ Grade ________

ADJUST DWELL WITH DWELL METER

Year and Make ______________ ______________

Engine Cylinders __________4 __________6 __________8

Point Specifications

Dwell Angle ______________ Point Gap ______________

ADJUSTING DWELL WITH DWELL METER

SOLID DISTRIBUTOR CAP

1. Ground high tension lead
2. Remove cap and rotor
3. Connect dwell meter
4. Loosen breaker point lockscrew
5. While observing dwell meter, crank the engine and adjust the points to the specified dwell angle.
6. Tighten point lockscrew
7. Reinstall the rotor and cap
8. Start and idle the engine and recheck the dwell setting. Readjust if required

Instructor's Initials __________

WINDOW DISTRIBUTOR CAPS

1. Distributor cap in place
2. Connect dwell meter to the ignition
3. Start and idle the engine
4. Raise window and insert 1/8 inch allen wrench into point adjustment screw.
5. While observing the dwell meter, turn the screw clockwise to increase dwell.
6. Remove wrench and close the window

Instructor's Initials __________

Electrical Competencies - Ignition System

No. E-13 Ignition System Adjustments

Worksheet # 3

Name ______________________________ Date ______________ Grade __________

Year and Make ______________________________ ______________________________

Engine Identification - Size ________________ Carburation ________________

Timing Specifications

STATIC TIMING

1. Locate and remove number-one spark plug
2. Bring the number-one piston to top dead center on the compression stroke and align the timing marks at the specifications.
3. Install the distributor so that the rotor points exactly at the number-one spark plub terminal of the cap.
4. Connect one lead of a test light to the coil distributor primary terminal and the other lead to ground.
5. Turn the ignition switch on. With the points open, the test light should come on.
6. Loosen the holddown bolt and rotate the distributor in the direction of rotor rotation until the light goes off.
7. Slowly rotate the distributor against rotor rotation until the light comes on.
8. Tighten the holddown bolt.

Instructor's Initials __________

Electrical Competencies - Ignition System

No. E-13 Ignition System Adjustments

Worksheet # 4

Name ____________________ Date ____________ Grade ________

Year and Make ____________________ ____________________

Engine Identification -- Size ______________ Carburation ______________

Distributor Direction of Rotation CW ______________ CCW ______________
Point Gap: ______________ in. Dwell ______________ degrees

INITIAL TIMING SPECIFICATIONS

Degrees at Idle ______________
Distributor Vacuum Line Removed or Plugged No ____________ Yes ____________
Combined Advance at 2000 rpm: ______________ Degrees

ANSWER THE FOLLOWING:

Is the dwell correct at 800 rpm?	No ________	Yes ________
Is the dwell correct at 2,000 rpm?	No ________	Yes ________
Does the centrifugal advance check out OK ?	No ________	Yes ________
Does the vacuum advance check out OK?	No ________	Yes ________
Is the combined advance correct to specifications (tolerance minus 2° to plus 8°)?	No ________	Yes ________

DYNAMIC TIMING

1. Check manufactures set-up procedures
2. Connect timing light and a tachometer to the engine
3. Clean and identify timing marks
4. Start engine and run at specified speed
5. Check the timing
6. Adjust as required
7. After timing adjustment, reconnect all vacuum lines and readjust the idle speed if necessary
8. Check centrifugal and vacuum advance covered in competency E-4

Instructor's Initials ____________

Electrical Competencies - Ignition System

No. E-13 Ignition System Adjustments

Worksheet # 5

Name ______________________ Date __________ Grade ________

Year and Make ____________________ ____________________

Engine Identification - Size ____________ Carburation ____________

Brand name and number disignation of spark plug ____________________

Gap specification (thousandths of an inch) ____________________

Torque specifications (pound - feet) ____________________

Did you find excessive cap erosion? Yes __________ No __________

Are the plugs:
Blistered ______________ Worn-out __________ Carbon-fouled __________
Oil-fouled ______________ Normal __________
Is the insulator cracked inside any of the plugs Yes ________ No ________
Is the insulator cracked outside any of the plugs Yes ________ No ________
Is the condition of the spark plug threads Bad ________ OK ________

SPARK PLUG REMOVAL

FOLLOW THIS GENERAL PROCEDURE TO REMOVE SPARK PLUGS:

1. Remove cables by grasping the plug boot and twisting gently while pulling. Do Not Pull on the cables.
2. Loosen each plug one to two turns and blow dirt away from plug with compressed air.
3. Remove plugs and place in order of cylinders
4. Remove old gasket from spark plugs
5. Clean and service spark plugs if needed

Instructor's Initials __________

SPARK PLUG INSTALLATION

1. Be sure gaskets are properly placed on plugs
2. Install plugs into the engine finger tight
3. Tighten the spark plugs to specifications
4. Attach spark plug cables

Instructor's Initials __________

Electrical Competencies - Ignition System

No. E-13Ignition System Adjustments

Worksheet # 6

Name ______________________________ Date __________ Grade __________

Year and Make __________________ ______________________

Air Gap Specifications ______________________ Inch

CHRYSLER ELECTRONIC DISTRIBUTOR AIR GAP ADJUSTMENT

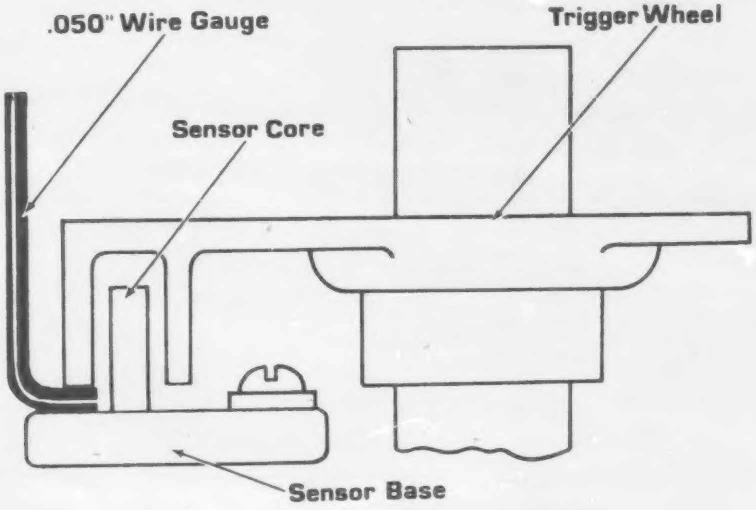
NOTE: A NONMAGNETIC FEELER GAUGE MUST BE USED.

1. Align a tooth on the reluctor with the pickup core.
2. Loosen the pickup coil adjustment lockscrew
3. Place .008 nonmagnetic feeler gauge between the reluctor blade and pickup core.
4. With screwdriver, shift distributor so the feeler gauge has slight drag
5. Tighten lockscrew
6. Check adjustment using .010 feeler gauge as a no-go gauge. The .010 gauge should not fit into the air gap.

Instructor's Initials ______________

AMERICAN MOTORS AND PRESTOLITE

1. Check sensor position -- sensor core should be midway between the teeth of the trigger



2. Use a .050 wire gauge to check for trigger wheel clearance from the sensor base. The rigger wheel may be adjusted up or down on the distributor shaft to achive this clearance.

Electrical Competencies - Ignition System

No.E-13 Ignition System Adjustments

Worksheet # 7

1. Breaker point alignment is accomplished by bending the ____________________ contact arm.

2. If spring tension is too light, the points will ____________________ as they open and close at high speed.

3. Dwell angle is the number of degrees in which the points stay _______________.

4. A ______________________________ gap increases the dwell.

5. A ____________ ________________ gap decreases the dwell.

6. List two ways that dwell can be measured.

   1.__________________________ 2.______________________ 3.____________________

7. New, properly aligned points can be set with reasonable accuracy using a __________________________________ ________________________.

8. Used points must always be adjusted using a __________________________ meter.

9. On distributor cap with windows the dwell angle can be set with the cap in ______________________________ and the engine ________________________.

10. A __________________ inch allen wrench is used for point adjustment on window distributor caps.

11. RFI shield stands for ____________________ ____________________________.

12. The RFI shield prevents radio interference signals from being picked up by the _________________________ _______________ ____________________.

13. The RFI sheild can be discarded when _______________ point assembly is being installed.

14. The allowable dwell variation ranges from as little as _______ degrees to as much as ___________ degrees, depending on the type of distributor.

15. List four common causes of excessive dwell variation:
    a.____
    b.____
    c.____
    d.____

16. Ignition timing can be adjusted __________________________, with the engine off, or ____________________________________, with the engine running.

17. One of the first steps when static timing is to bring the number-one piston to top dead center on the __________________________ stroke and align the timing marks.

Worksheet # 7
Page 2

18. Dynamic timing is preformed with a ______________ ______________.

19. A timing light is triggered by voltage from the ____________________ spark plug.

20. Engine must be at ______________ temperature before timing is adjusted.

21. The timing is set on most engines with the distributor vacuum lines ____________________ and ____________________.

22. On late model engines, the timing setting is given on the engine tune-up ____________________.

23. Before adjusting the advance mechanisms, the distributor should be __________, ______________, and ____________________.

24. Adjust ______________ advance before ______________ advance.

25. List four things that effect spark plug life:
    a. ______________________________
    b. ______________________________
    c. ______________________________
    d. ______________________________

26. File the center electrode of the spark plug until it is __________ and the inside surface of the ground electrode unit until a ______________ surface appears.

27. Both new and used spark plugs must be __________ to the engine manufacturer's specifications.

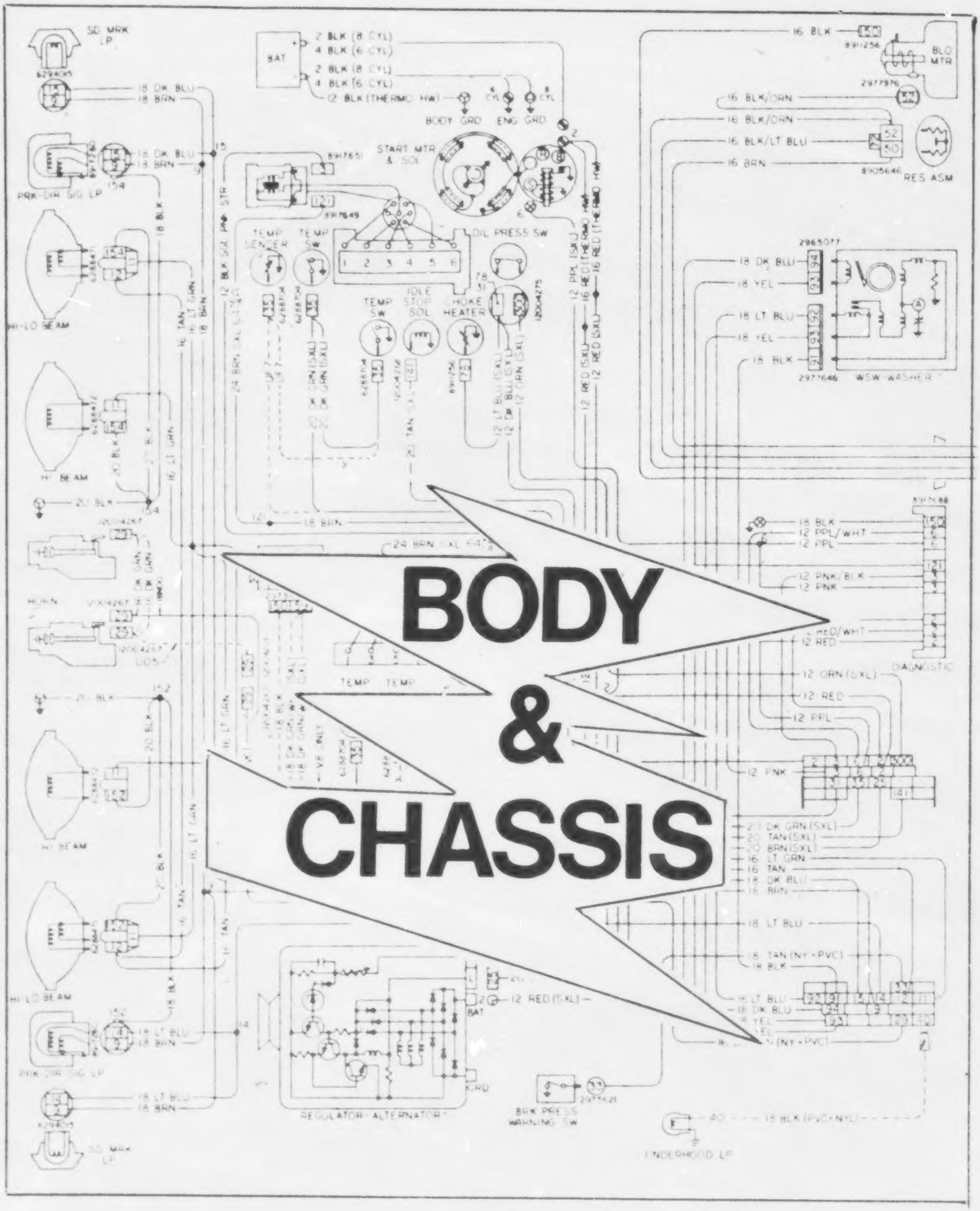
28. Spark plugs used with many electronic ignition systems require wide gaps in the ______________ to ______________ inch range.

29. Use a __________ __________ feeler gauge to measure the spark plug gap.

30. Bend only the ______________ electrode to adjust the gap.

31. The air gap between the __________ and ________ ________ is adjustabl

32. A ______________ feeler gauge must be used to adjust an air gap.



BODY & CHASSIS

SD MRK LP
6294015
18 DK BLU
18 BRN
PRK-DIR SIG LP
HI-LO BEAM
HI BEAM
20 BLK
HORN
BAT
2 BLK (8 CYL)
4 BLK (6 CYL)
12 BLK (THERMO HW)
BODY GRD
ENG GRD
START MTR & SOL
OIL PRESS SW
TEMP SENDER
TEMP SW
IDLE STOP SOL
CHOKE HEATER
16 BLK
BLO MTR
16 BLK/ORN
16 BLK/LT BLU
16 BRN
RES ASM
18 DK BLU
18 YEL
18 LT BLU
18 BLK
WSW-WASHER
18 PPL/WHT
12 PPL
12 PNK/BLK
12 PNK
12 RED/WHT
12 RED
DIAGNOSTIC
12 ORN (SXL)
12 RED
12 PPL
12 PNK
20 DK GRN (SXL)
20 TAN (SXL)
20 BRN (SXL)
16 LT GRN
16 TAN
18 DK BLU
18 BRN
18 LT BLU
18 TAN (NY+PVC)
18 BLK
12 RED (SXL)
REGULATOR-ALTERNATOR
GRD
BRK PRESS WARNING SW
2977621
UNDERHOOD LP
18 BLK (PVC+NYL)

REFERENCE

The texts chosen were selected because they are in current use by the instructors who compiled this manual. You should have a copy of at least one in your shop.

The text books are to be used as references for each exercise in this book. For each exercise you will find a number followed by page numbers. Look up the book number on this list and the page numbers will correspons to the exercise you are working. For example of you find 5. 103-211 in the reference section you would check this reference list and find that book No. 5 is Auto Mechanics by H. E. Ellinger. In that book, pages 103-211 will apply to the exercise you are working.

	TEXT	AUTHOR	PUBLISHER
1.	Auto Service and Repair 1975	Stockel	Goodheart - Willcox
2.	Auto Mechanics Fundamentals 1974	Stockel	Goodheart - Willcox
3.	Motor Auto Engines and Electrical Systems 1975	Hearst Corporation	Motor
4.	Automotive Encyclopedia 1975	Tobotdt - Johnson	Goodheart - Willcox
5.	Auto Mechanics Second Edition	Ellinger	Prentice - Hall
6.	Automotive Mechanics	Crouse	McGraw - Hill
7.	The Auto Book	Crouse	McGraw - Hill
8.	Automotive Chassis And Accessory Circuits	Brezcha/Samuels	Prentice - Hall

Auto Mechanic's
Body and Chassis
No. F Index

F-1 Perform Operational Inspection

F-2 Locate and Replace Electrical Components

F-3 Lamp Replacement

F-4 Headlight Aiming

F-5 Connect Trailer Lights Coupling Connector

F-6 Wire a Trailer

F-7 Interpret Wiring Diagrams

F-8 Identify Circuit Feedback

F-9 Common Point Diagnosis Using a Wiring Diagram

F-10 Perform Systematic Diagnosis and Testing

F-11 Identify & Diagnose Head, Tail, & Backup lights

F-12 Identify & Diagnose Turn, Hazard, Stop, & Cover Lights

F-13 Identify & Diagnose Dome & Convenience Lights

F-14 Identify & Diagnose Small Motors & Circuits

F-15 Identify & Diagnose Horn & Buzzers

F-16 Identify & Diagnose Gauges & Indicators

F-17 Identify & Diagnose Power Accessory Circuits

SCHOOL ____________________ STUDENT ____________________

INSTRUCTOR ____________________ YEAR GRAD ____________________

AUTOMOTIVE ELECTRICAL COMPETENCIES-BODY & CHASSIS

	COMPETENCY	JR	M	C	SR	M	C	VOC	M	C	IND	M	C
F-1	Perform Operational Inspection												
F-2	Locate and Replace Electrical Components												
F-3	Lamp Replacement												
F-4	Headlight Aiming												
F-5	Connect Trailer lights Coupling Connector												
F-6	Wire a Trailer												
F-7	Interpret Wiring Diagrams												
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F-12	Identify & Diagnose Turn, Hazard, Stop, & Corner Lights												
F-13	Identify & Diagnose Dome & Convenience Lights												
F-14	Identify & Diagnose Small Motors & Circuits												
F-15	Identify & Diagnose Horn & Buzzers												
F-16	Identify & Diagnose Gauges & Indicators												
F-17	Identify & Diagnose Power Accessory Circuits												
18													
19													
20													
21													

THIS COMPETENCY SHEET LISTS ALL THE SKILLS REQUIRED FOR THIS BOOK. THEY ARE LISTED IN A LOGICAL ORDER ALTHOUGH THERE IS NO FIXED SEQUENCE FOR COMPLETING THE EXERCISES. EACH HEADING HAS A COLUMN TO ITS RIGHT WITH SPACES TO ALLOW GRADING AFTER YOU COMPLETE THAT EXERCISE. WE HAVE TAKEN INTO ACCOUNT THAT NOT EVERY EXERCISE WILL BE COMPLETED THE FIRST YEAR. THEREFORE, WE HAVE SPOTS FOR JUNIOR, SENIOR, VOCATIONAL AND INDUSTRY. AS YOU COMPLETE A PARTICULAR COMPETENCY, (OR TASK) YOU WILL BE GRADED ACCORDING TO THE SCALE AT THE BOTTOM OF THIS SHEET. ALSO, IF THERE ARE ANY MATH OR COMMUNICATION SKILLS REQUIRED THEY CAN ALSO BE GRADED USING THE CODE N, 1, 2, OR 3. THE DATE OF COMPLETION WILL BE ENTERED UNDER THE APPROPRIATE YEAR AND COMPETENCY. YOU WILL HAVE THE OPPORTUNITY TO UPGRADE ANY ONE OF THESE SKILLS AT ANY TIME AFTER YOU FIRST COMPLETE THE TASK AND HAVE THE NEW RATING ENTERED ON THIS SHEET.

RATING SCALE

N = No opportunity to perform
1 = Completed exercise with close supervision
2 = Completed exercise with little supervision
3 = Completed exercise without supervision

M = Math
C = Communications

SCHOOL____________________ STUDENT____________________

INSTRUCTOR____________________ YEAR GRAD____________________

AUTOMOTIVE ELECTRICAL COMPETENCIES-BODY & CHASSIS

	COMPETENCY	JR	M	C	SR	M	C	VOC	M	C	IND	M	C
F-1	Perform Operational Inspection												
F-2	Locate and Replace Electrical Components												
F-3	Lamp Replacement												
F-4	Headlight Aiming												
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INTRODUCTION

Body and Chassis wiring is often the most neglected area in automechanics education. In the past, it has been left up to the technician to learn his way through this area by trial and error methods. Since many mechanics, using these methods, have given up in frustration, there is a need for skilled personnel to service the numerous lighting systems and power accessories found on today's automobiles.

Actual work on body and chassis wiring is not always consistent. The different types of problems are as numerous as the number of circuits used multiplied by the number of automobile models available from the manufacturers. These problems demand a broad range of skills which may range from replacing a simple light bulb to interpreting a wiring diagram and using logical test methods to locate a problem.

Since many of the electrical service jobs may fall somewhere in-between the two extremes, this section of competencies attempts to span the gap and provide some additional links in a chain of electrical servicing skills.

Many of the more advanced competencies in this area assume that you have a good grasp of fundamental electrical principles and testing skills. Because of this, it is strongly recommended that you complete all of the competencies in section A before proceeding to the more advanced areas.

AUTO MECHANICS

Electrical Competencies- Body & Chassis

No F-1 Operational Inspection

OBJECTIVE:

Upon completion of the following material, you will be able to perform complete body and chassis electrical system operational check with 100% accuracy.

EXPLANATION:

This unit will involve a visual and audio check of lighting, safety, and accessory electrical circuits operation.

MATERIALS NEEDED:

TOOLS NEEDED:

References		Do	
#1.	--	#1.	Study assigned references.
#2.	Ch. 5, p.105 Ch. 19, p. 398-401 Ch. 6, p. 121 Ch. 4, p. 84-85	#2.	Study information sheets.
#3.	p. 690-708 p. 442-451 p. 464-473	#3.	Perform and record operational check of all available systems on a live vehicle.
#4.	p. 427-436 p. 291-292 p. 462-466	#4.	Record your observations on the worksheet.
#5.	Ch. 32, p. 522-535	#5.	Turn worksheet in for instructor check.
#6.	Ch. 34, p. 322-333 Ch. 60, p. 598-610	#6.	
#7.	Ch. 23, p. 287-297	#7.	
#8.	Ch. 8, p. 174-217 Ch. 10, p. 246-247, 254, 256,257-258, 261-265, 272-273 Ch. 11, p. 277, 291-292 Ch. 12, p. 321-322, 334, 347 Ch. 13, p. 350-352	#8.	

Electrical Competencies- Body & Chassis

No. F-1 Operational Inspection

Information Sheet #1

Lighting Systems

Lighting systems can be divided into two groups, those required by law and those which are installed for the convenience of the driver or passengers.

Required Lighting

Must be operational or owner will be subject to penalties.
Headlights (2), taillights (2), stoplights (2) left turn signal, (front and rear), right turn signal, (front and rear), license plate light (rear), 4-way hazard warning lights, back-up lights (since 1967), body side marker lights, parking lights, (front, on with headlights) (since 1968)

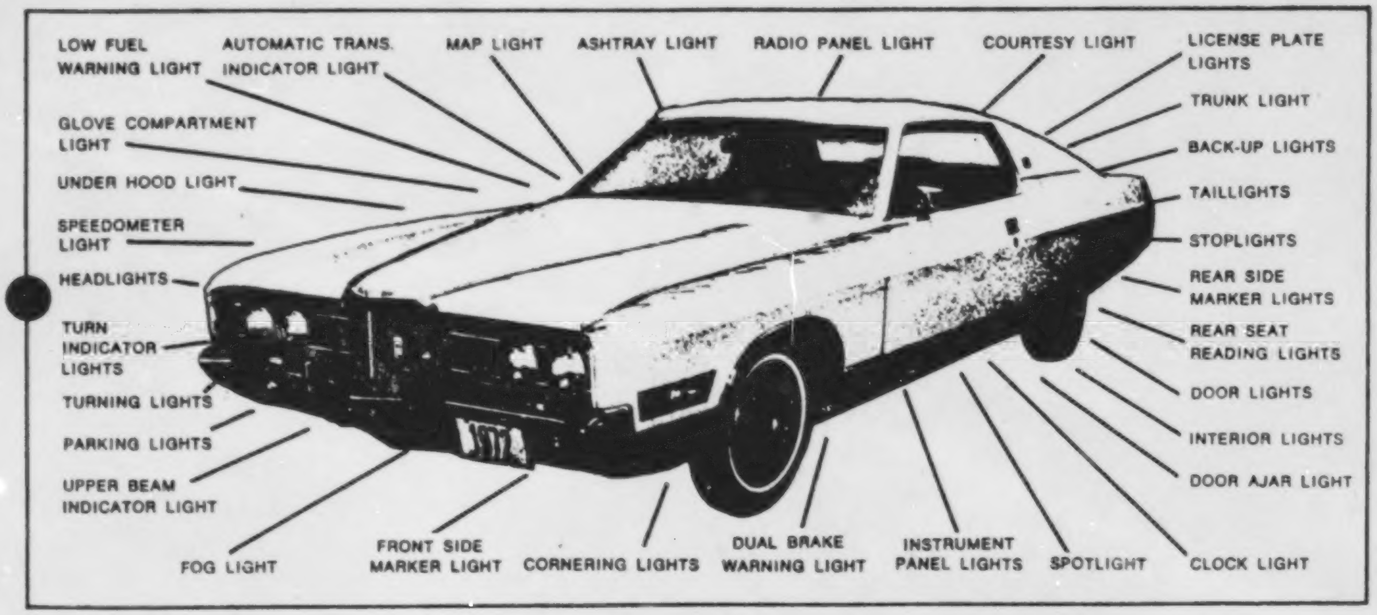
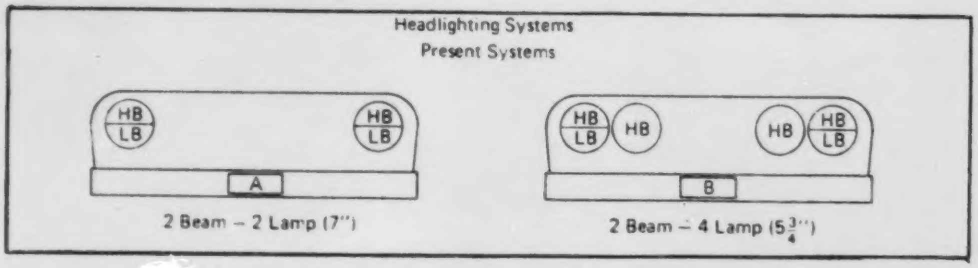

LOW FUEL WARNING LIGHT
AUTOMATIC TRANS. INDICATOR LIGHT
MAP LIGHT
ASHTRAY LIGHT
RADIO PANEL LIGHT
COURTESY LIGHT
LICENSE PLATE LIGHTS
TRUNK LIGHT
BACK-UP LIGHTS
TAILLIGHTS
STOPLIGHTS
REAR SIDE MARKER LIGHTS
REAR SEAT READING LIGHTS
DOOR LIGHTS
INTERIOR LIGHTS
DOOR AJAR LIGHT
CLOCK LIGHT
SPOTLIGHT
INSTRUMENT PANEL LIGHTS
DUAL BRAKE WARNING LIGHT
CORNERING LIGHTS
FRONT SIDE MARKER LIGHT
FOG LIGHT
UPPER BEAM INDICATOR LIGHT
PARKING LIGHTS
TURNING LIGHTS
TURN INDICATOR LIGHTS
HEADLIGHTS
SPEEDOMETER LIGHT
UNDER HOOD LIGHT
GLOVE COMPARTMENT LIGHT
1972

Fig. 8.1. **A modern American produced passenger car showing a multitude of light bulbs used to illuminate everything from the roadway to the ashtray. Statistics show that nearly 80 percent of all older model cars have some kind of lighting defect or problem, 50 percent of which consist of burned out or mis-aimed headlights. Others include burned out small bulbs, fuses and turn signal flashers, damaged or broken lenses, and corroded, rusted or damaged connectors or housings.** *(Courtesy of Ford Customer Service Division.)*

Headlights

Headlight systems may consist of a
(1) two lamp, two beam system using two round 7" lamps
(2) four lamp, two beam system using four round 5 3/4" lamps
(3) two lamp, two beam system using two rectangular lamps
(4) four lamp, two beam system using four rectangular lamps



The two beam system consists of a low beam and a high beam.

(1) The total forward version on low beam is less intense and more spread out to provide better roadway illumination in urban areas.

(2) The high beam adds concentrated light to the right and center of the roadway, increases illumination, and enables the motorist to see traffic signs on the side of the roadway.

Headlamp Switch

The headlamp switch is an operator-actuated device for control of various vehicle light sources. Its primary function is to control headlights, parking lights, taillights, and certain marking lights. A secondary function may be to control various accessory and instrument lights. Circuit breakers may be incorporated for circuit overload protection.

The switch is a "push-pull" type that includes a rheostat for controlling the brightness of the instrument panel lights, and a detent position for the dome and courtesy light circuit. The switch knob "push-pull" positions control the light circuits as follows:

1. Parking Position (knob pulled out to the first notch) turns on the parking lights, taillights, license light, side marker lights, and instrument panel lights. The rheostat, controlled by turning the knob, must be set properly for the instrument panel to turn on.

2. Driving Position (knob pulled out to last position) turns on the headlights while the other lights remain as in the parking position.

3. Dome Light Position (knob turned fully counterclockwise) turns on the dome and courtesy lights regardless of the in or out position of the switch.

Dimmer Switch

The dimmer switch provides the means to change from low beam to high beam operation. During low beam use, only two of the lamps will be in operation. In a four lamp system, these will be in the outboard or upper position. During high beam use, all lamps will be lighted, including the high beam indicator light found on the dash board. Newer model cars are now being equipped with a dimmer switch located in conjunction with the turn signal lever.

Parking lights, taillights, and license plate lights

The parking lights, taillights, and license plate lights are steadily burning, low-intensity lights. These light circuits are energized whenever the headlight switch is in the park or the driving position.

The parking lights are mounted on the left and right front of the vehicle to mark the vehicle when parked. They also serve as a reserve front position marking system in case of a headlight failure. The taillights are used to designate the rear of the vehicle. Parking light units also double as turn signals, while the taillight units are often used for both stop light and turn signal.

Side Marker Lights

For added nighttime driving safety, exterior automobile lighting now includes side marker lights. An amber-lensed light is used on the left and right sides of the vehicle front and a red-lensed light on the left and right sides of the vehicle rear. These lights glow continuously when the parking lights or headlights are on.

On some later model designs the side marker lights are interconnected with the turn signal system. During turn signal operation with the parking lights off, the side marker lights will flash simultaneously. During turn signal operation with the parking lights on, the side marker lights will flash alternately.

Cornering Lamps

Cornering lamps are steadily burning lamps used in conjunction with the turn signal system to supplement the headlamps by providing additional illumination in the direction of turn. They make the car more visible to other drivers approaching from the side and also improve the visibility of nearby objects not illuminated by the headlights during the turn. These lamps are mounted, one on each side, in the forward position of the front fenders.

Cars with cornering lamps require a different turn signal switch which provides an additional set of switching contacts for the cornering circuit only. When either the parking lights or the headlights are on, moving the turn signal level for a left or right turn also causes a cornering light to come on in the direction of the turn. Since there is no circuit flasher, the light does not blink and remains on until the turn is cancelled.

Turn Signals

The turn signal circuit consists of the switch and flasher, two signal indicator bulbs on the instrument panel, the stoplight filaments in the rear lighting, and the turn signal filaments in the parking light bulbs and front side marker lights.

Some recent American models and most import automobiles use an amber colored rear turn signal unit which is separate from the stop light circuit. In this type, only the stop light filament remains with the taillight unit.

The circuit is controlled by the turn signal switch, which is mounted in a housing at the upper end of the steering column just below the sterring wheel. When the turn signal switch is operated to indicate a turn or a lane change, the front and rear signal lights and the front side marker lights flash on and off on the left or right side of the car, as chosen by the driver. A turn indicator bulb on the instrument panel also flashes with the turn signal lights.

After a turn is completed, the return of the steering wheel to a straight-ahead position cancels the signal circuit. On slight turns such as those used in a lane change, the return of the steering wheel to a straight-ahead position will not cancel the circuit. This is normal and the signal switch must be returned to its neutral position by the driver.

The on/off flashing of the bulbs is caused by a turn signal flasher device in the circuit. The flasher is a very simple thermostatically activated circuit breaker. Its normal flash rate varies between 60 and 120 flashes per minute. If the flash rate is much faster or much slower, it indicates a problem in the circuit which must be corrected. For example, a system that does not flash on one side will indicate a burned out bulb, when the standard duty flasher unit is used. A heavy duty flasher unit, available for trailer towing, does not change its flash rate even though several bulbs may be burned out in the system or added to the system beyond its original design number. The use of a heavy duty flasher requires a periodic inspection of the bulbs.

Hazard Warning Lights

All cars manufactured in production year 1967 or later are equipped with a system of warning lights to signal any unusual or dangerous condition, such as a disabled car stopped by the side of the road, or some other emergency situation. The hazard warning feature, when turned on, causes all turn signal lights plus the indicator lights to flash simultaneously.

This system is integrated into the turn signal circuit and makes use of the regular turn signal wiring and lights, but has a separate power supply, flasher unit, and on-off switch. The switch is usually located just below the steering wheel on the right side of the steering column or it may be found on the instrument panel.

Stoplights

The stoplight was probably the first signaling device used on the automobile. It provides a steady bright light to the rear of the vehicle to indicate that the operator intends to stop the vehicle or slow the speed by braking.

Present stoplight circuits employ at least two lights. The stoplights are controlled by a mechanical switch mounted on the brake pedal bracket. When the switch is activated by the brake pedal, the circuit is completed through the turn signal switch and high-current filament in the taillight bulbs; dual filament bulbs with trade numbers 1157 or 1034 are used. The same high-current filaments in the taillight bulbs are also employed as the light source for the turn signal and hazard warning circuits.

On older vehicles the brake light switch is generally located in the brake line at the master cylinder and is activated by hydraulic pressure build-up when the brakes are applied.

Backup Lights

Backup lights illuminate the road to the rear of the vehicle and provide a warning signal to pedestrians and other drivers when the vehicle is backing up or about to back up.

When the driver puts the car into reverse, this closes the backup light switch contacts within the neutral safety switch, and completes circuit to the backup lights. Backup light switches are usually found under the dash on the steering column or on the left side of the transmission. The ignition key must be on for circuit power.

Dome, Courtesy, Glove Box Lighting

Dome and courtesy lights are installed to light the interior of the vehicle for the convenience of the occupants. The courtesy lights are located to light the floor areas and may be an option on some models. These lights are activated by spring loaded plunger type switches on the door jams and also through the headlight switch knob rotation. The glove box light is also operated with a spring loaded plunger type switch.

Trunk and Under Hood Lighting

Lamps may be installed inside the trunk or under the hood on some vehicles. These lamp fixtures contain a mercury switch which reacts to the tilt angle of the open trunk or hood, turning the lamp on when opened.

Instrument Panel Lights

The instrument panel lights provide indirect lighting to illuminate the speedometer, instrument gauges, heat-defroster controls, air-conditioner controls, ash tray, clock, and transmission control dial.

The instrument panel lights are controlled by the headlight switch, which incorporates a knob-operated rotating rheostat to adjust the light brightness.

On some Chrysler cars using a throw-type headlight switch, a separate instrument panel dimmer switch is mounted on the dash. The circuit, however, remains basically the same.

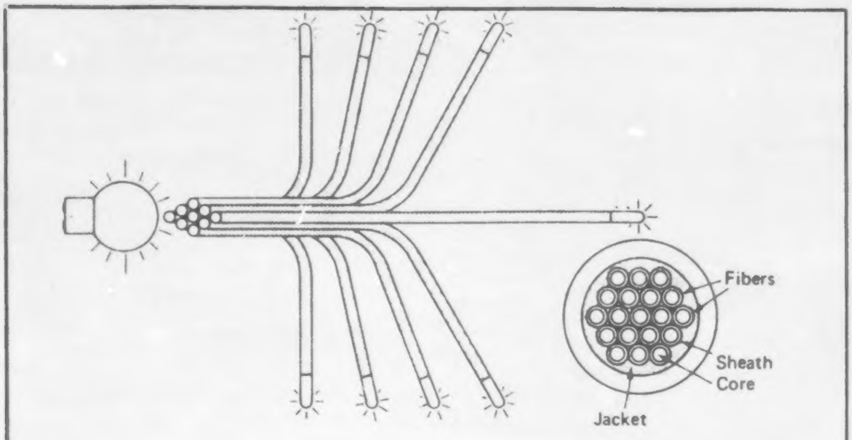
Instrument Panel Indicator Lights

Other instrument panel lights are used to moniter vehicle systems and as warning indicators for the driver. Some of the more common indicator lights include low oil pressure, cold and hot engine temperature, fasten seat belt warning light, turn signal indicator, and a high beam on indicator. Others may indicate certain accessories in use and provide reminders for maintainance items. Normally "off" lights such as brake warning and hot temperature lights can be proved when the ignition switch is held in the start position.

Fiber Optics

Fiber optics is a method of providing illumination by a single light source acting at a distance from the objects to be illuminated. The single light source is transmitted to the object to be illuminated by a special type of optical cable consisting of strands of plastic material known as polymethyl-methacrylate. These strands are sheathed by a transparent polymer that acts to insulate the bouncing light rays as they travel within the strands; the cable is further enclosed in a flexible opaque outer sleeve. The fiber cable acts as a light conductor; light rays produced by the light source travel in a zig-zag path by internal reflections along the cable and produce a source of illumination at the other end of the cable. The light intensity at the cable exit can be increased by simply increasing the number of fiber strands. The fiber cable itself can be bent and twisted in any number of positions and can be used for short or long runs without affecting the light conductance.

Fiber optics can provide a lighted area wherever desired, particularly in places where ordinary small bulbs would be inaccessible for service replacement. On a limited basis fiber optics applications are found on instrument faces, dash lighting over switches, and even in the front and rear lighting of some vehicles.



Fiber Optics

Horns and Buzzer Warning Systems

There are many types of warning systems in the modern automobile. They may be manually operated such as the horn which uses an activator bar mounted across the steering wheel. Or the automatic type such as the buzzer which reminds the driver that the key has been left in the ignition switch. Another warning system is the light or buzzer that tells the passengers and/or driver to fasten their seat belts. In some cases the seat belt warning system will present the driver from starting the engine until the belt is fastened.

Electric Windshield Wiper and Washer

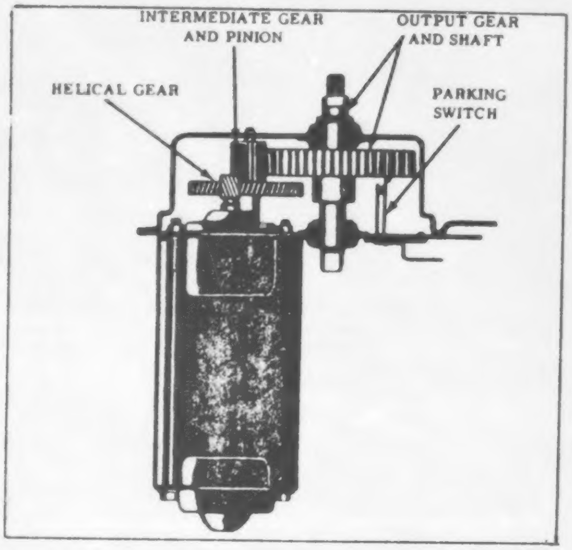
Windshield wipers were one of the first safety divices used on automobile vehicles. Electric windshield washers are tied into the wiper system as a standard safety item; they are operated either by a pump attached to the windshield wiper motor or by means of a separate motor-driven pump mounted on the solvent reservoir. Control of the washer system is usually integrated into the windshield wiper switch. A tailgate wiper and washer system is available as a factory option on some station wagon makes and models.

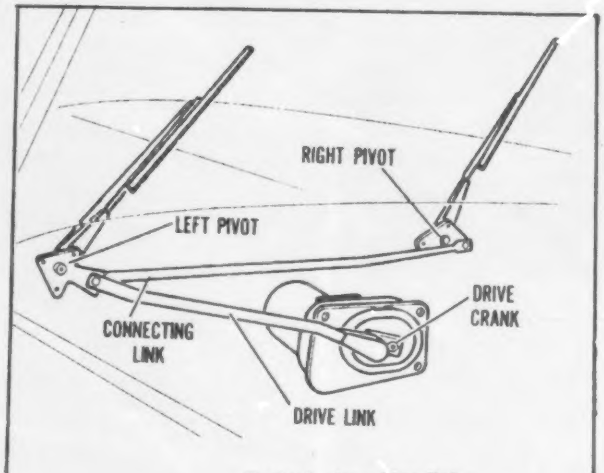
Wiper Motor Gear and Linkage Drives

All wiper motors have an attached gear box containing a parking switch in addition to the gear train. The gear train functions to give the wiper motor a torque boost and reduce motor speed. A cam mechanism is incorporated in each gear train to operate the park point switch. The park point switch ties in with the wiper switch on the dash and opens the motor circuit when the wiper blades reach their exact position at the end of the wipe cycle.

The drive linkage arrangement in Fig. 13-3 is typical of most wiper systems. Attached to the motor drive is a crank arm that connects to a drive link and wiper pivot (the left pivot in the illustration). To complete the hook-up, a connecting link couples the left windshield wiper pivot to the pivot at the right side of the car.

On depressed park applications, where the blades park off the glass when the final wipe cycle is completed, the overtravel feature (disappearing act) is incorporated in either the crank arm and drive link or in the motor assembly itself.





Typical wiper drive linkage. *(Courtesy of The Chrysler Corporation)*

Instrument Panel Gauges

Instrument gauges monitor various vehicle operating systems and keep the driver informed of their correct operation. The more essential instruments are concerned with the fuel level, engine coolant temperature, oil pressure, charging rate and vehicle speed. Basic instrument operation is based on either thermoelectric or electromagnetic priciples. Linked electrically to each gauge is a sending unit which senses operational changes in the device it is monitoring. The sending unit varies resistance and changes the indicator position in the gauges accordingly.

The thermoelectric type gauges are found on American Motors, Ford,and Chrysler products. With the ignition switch in the "off" position, normal gauge indicator position is off scale to the left below the first dial marking (except ammeter). With the ignition "on", engine not running, the fuel gauge will read fuel quantity and the ammeter will be deflected slightly to the left of center. With the engine running, the oil pressure gauge will read normal oil pressure and the temperature gauge will indicated the operating temperature of the engine at that particular time.

Electromagnetic type gauges are found on General Motors automobiles. Gauge indicator operation is similar to the thermoelectric gauge except for one difference. With the ignition switch in the "off" position, the indicator is allowed to float across the dial and seek its own resting point. The indicator may eventually come to rest at either the high or the low end of the dial. If the indicator isa at a balance point it may not move at all from its last reading. These characteristics are normal for this type of gauge.

Heater/Air Conditioning Blower Motor

Forced air circulation for the heating and air conditioner system is supplied by a motor driven fan. The motor is controlled by a multiposition switch located on the heating A/C control panel. The switch provides a low, medium, and high speed ventilation designs have eliminated an "off" function of the switch on many models.

Seat-Belt-Starter Interlock System

The seat-belt-starter interlock system is designed to prevent engine start when the right-front passenger seat and/or the driver's seat are occupied and the seat belts are not fastened.

Seat-Belt-Interlock System- Operation

Three waffle-type seat sensors are located under the seat cushion of the front seat (Fig. 10-18, #10). Each of the three belt buckles in the front seat has a built-in switch.

Fig. 10.18. System components and location. *Courtesy of General Motors Corp.*

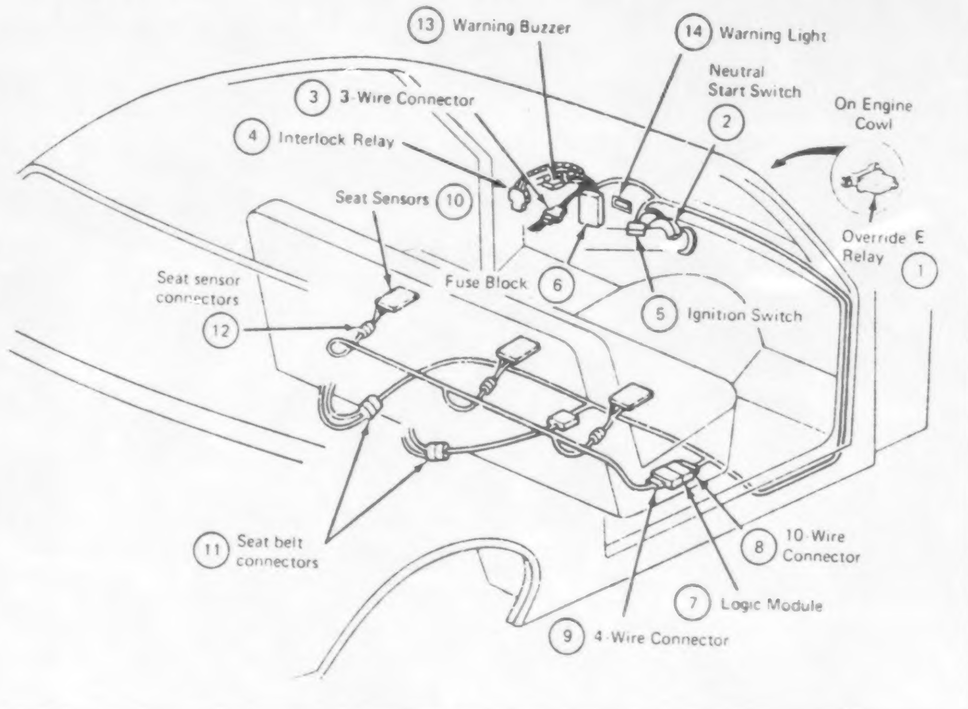

13 Warning Buzzer
14 Warning Light
3 3-Wire Connector
Neutral Start Switch 2
On Engine Cowl
4 Interlock Relay
Seat Sensors 10
Override E Relay 1
Seat sensor connectors 12
Fuse Block 6
5 Ignition Switch
11 Seat belt connectors
8 10-Wire Connector
7 Logic Module
9 4-Wire Connector

Figure 10-18 shows other components of the system: an electronic logic module located under the front seat (#7); an interlock relay mounted close to the fuse block (#4); a buzzer that plugs into a connector (#13); a warning light located in the instrument cluster (#14); and an override relay located on the driver's side under the hood (#1).

Remember that (1) the interlock relay points are normally closed and (2) current is continually fed to the electronic logic module through the clock fuse. To start the engine:

1. Sit on the seta.
2. Fasten the seat belt.
3. Start the engine

If the right-front seat is occupied before the engine is started, the seat belt must also be buckled before the engine can be started.

As the driver's seat and the right front outboard seat are occupied, the respective seat sensors inform the logic module and the interlock relay contacts are opened.

When the seat belts are fastened, the buckle switches inform the logic module and the interlock relay contacts are again closed, With the shift lever in park or neutral and the ignition turned to start, current is fed through the backup lamp and the seat-belt warning switch to the interlock relay and then to the solenoid.

General Motors, Chrysler, and AMC have the belt sensors in the buckle. Ford places the sensors in the belt retractor.

Override relay

The override relay permits you to start the engine in the event of a failure in the interlock system. To activate the override relay, turn the ignition key to "on". Open the hood, press and release the start button on the override relay, and then turn the ignition key to start the engine.

Mechanic's Start

A mechanic's start procedure can be used to turn over the engine without first having to occupy the front seat or be concerned about whether the belts are buckled. You can start the engine by reaching into the car and turning the ignition switch to start. The warning system will not operate unless the car is placed in a drive mode.

Seat-Belt-Starter Interlock Legislation

The seat belt-starter interlock system was required by Federal law (Motor Vehicle Safety Standard #208) in vehicles built after 1973. This law was amended to permit silencing of the continuous buzzer and bypassing of the interlock, but it does not allow extinquishing of the seat-belt warning light. Therfore, reaching under the seat and pulling apart the connector to the seat sensor is prohibited, for the light also would affected.

An amendment to the Federal Motor Vehicle Safety Standard #208 stipulates that passenger vehicles produced on or after February 24, 1975, must be equipped with a nonswquential 408 second seat-belt warning light and buzzer system that is activated from the driver's seat only. The new system has an instrument panel warning light that lights up every time the ignition switch is turned on, whether or not the driver's seat is buckled, but which automatically goes off after 4-8 seconds. The buzzer also is controlled by the 4-8 second timer but operates only if the driver has not buckled up. If the driver does not buckle up after turning on the ignition, the buzzer also shuts off automatically after 4-8 seconds.

Cigar Lighter

A cigar lighter is an accessory item consisting of a resistance type heating element installed in a socket mounted in the dash panel. Additional mounting points may be found in the rear seat area. To operate depress the lighter and it will automatically heat and snap out ready for use. Avoid holding the lighter in by hand while it is heating as damage to the heating element may result.

Radio and Power Antenna

The radio is one of the most common accessories. It may be merely an AM radio or a complex AM/FM stereo with tape clock. The automotive technicians main responsibility in checking the system is to make sure the push buttons on the front of the radio are working. Also the on-off and volume dial along with the tune-in dial are functioning properly.

On auto's equipped with a power antenna, the raising and lowering of it may be done by a button located on instrument panel or by the on-off switch on radio.

Electric Back Window Grid Defogger

The optional back window grid defogger system consists of a tinted glass that has a number of horizontal ceramic silver compound element lines and two vertical bus bars baked into the inside surface during the glaze-froming operation. Braided wire is soldered to the bus bars on each side of the glass. The lead wires are spliced to the braided wire and covered with an extruded plastic sleeve to insulate them from body material.

Under some conditions, heat from the glass may not detected by finger touch. The length of time required to remove interior fog from the back glass varies with conditions such as vehicle speed, outside glass temperature, atmospheric pressure, number of passengers, etc.

The system utilizes an instrument panel-mounted switch with an integral indicator lamp. Once the switch has been activated, the system will operate continuously until the switch or the ignition is turned off. A relay is used in conjunction with the air conditioning system to regulate the blower motor speed when the heated back glass is in operation. On some styles the system will operate for approximately ten minutes and then will be automatically turned off by a timer. When the electric back window grid defogger is turned on, the blower motor will return to low speed.

Power Windows

A power window option can be obtained for most American manufactured automobiles. Withe this option, all vertically moving windows are controlled by the power window control switches located on the left front door. Individual switches are provided under each window for passenger use. Switches are wired through the ignition switch so that windows cannot be operated unless the ignition switch is "on"

A power rear window is often found on station wagon models. Control switches in this case are found on the instrument panel and incorporated with the rear external key lock.

Power Seat

Four way and six way power seats make use of electric motors to provide a variety of seating posiitons. Seat control is provided by a switch located onthe left front door. Some models provide a split seat with an individual control on the passenger side. Seat operation is provided by moving the seat switch in the corresponding direction. When the switch is released, the seat is locked into position.

Electronic Cruise Control

An electrically controlled vacuum operated cruise control is available as a production option or an add on accessory for many automobile models. The cruise control system allows the driver to select and automatically maintain a speed of 30 mph or higher thus increasing comfort and economy when driving on turnpikes, expressways and other non-congested highways.

The cruise control system is activated by accelerating to the desired speed, then depressing and slowly releasing the control button located on the end of the turn signal lever. The car's speed will be maintained automatically without pressure on the gas pedal.

The automatic control system is instantly released by light application of the brake pedal or by turning the ignition system off. A speed setting decrease can be obtained by holding in the engagement button while decellerating to the desired speed.

Electric Trunk Release

On many late model American made automobiles an electric trunk release is available. This switch permits the opening of the trunk lid without the use of a key. Usually a release button is located in the glove box.

Electric Door Locks

Manufacturers have made the locking of doors by the occupants either manual or electric. We are concerned with checking the electric type. The testing of this unit can be done by turning the ignition switch on and operating the switch marked "Lock" on the door trim pad. Remember that the automatic locking mechanism does not at any time interfere with manual operation of any door lock button.

Electric Clock

An operational check of an electric clock in your vehicle is quite easy because it sould be running at all times. The automatic regulation unit thats built-in to the design of most clocks, automatically re-adjusts it if its running too fast or too slow.

Tachometer

The tachometer is another of the many options a buyer can purchase for an automobile. Its function is to indicate the speed of the engine in revolutions per minute (RPM). Usually the tach has a red portion on its face, that the manufacturer recommends you start below. This meter may be checked by starting the vehicle and observing the movement of the needle during engine acceleration.

Electrical Competencies- Body & Chassis

No. F-1 Operational Inspection

Worksheet #1

Name ______________________ Date ____________ Grade __________

Vehicle Make ______________________ Year _________

Instructions; Make an operational inspection of the lighting and electrical system of an automobilt. Check "OK" if the system is operating properly. If not, check "Repair" and comment on the problem.

Item	OK	Repair
1. Head lights		
2. Parking lights		
3. Tail lights		
4. License plate light		
5. Side marker lights		
6. Cornering Lights		
7. Turn signals		
8. Stop lights		
9. Back-up lights		
10. Head lamp switch		
11. Dimmer Switch		
12. Turn signal switch		
13. Hazard Warning lights		
14. Dome light		
15. Courtesy lights		

Electrical Competencies- Body & Chassis

No. F-1 Operational Inspection

Worksheet #1
Page 2

Item	OK	Repair
16. Glove box light		
17. Trunk light		
18. Hood light		
19. Instrument Panel lights		
20. Instrument panel indicator lights.		
21. Fiber optics		
22. Horns		
23. Buzzers		
24. Windshield wipers		
25. Windshield washers		
26. Instrument panel gauges		
27. Air conditioner blower motor		
28. Seat-belt-starter interlock system		
29. Cigar lighter		
30. Radio		
31. Power antenna		
32. Rear Window Defogger		

Electrical Competencies- Body & Chassis

No. F-1 Operational Inspection

Worksheet #1
Page 3

Item	OK	Repair
33. Power windows		
34. Power seat		
35. Cruise control		
36. Trunk release		
37. Door locks		
38. Clock		
39. Tachometer		

Instructor's Initials ___________

AUTO MECHANICS

Electrical Competencies- Body & Chassis

No. F-2 Locate and Replace Electrical Components

OBJECTIVE:

Upon completion of the following material, you will be able to locate power distribution circuits, fusible links, fuses, and flashers, and replace fuses turn sugnal flashers, and hazard warning flashers.

EXPLANATION:

This unit covers information which will be helpful in locating the more commonly serviced electrical components.

MATERIALS NEEDED:

TOOLS NEEDED:

Fuse remover tool

References	Do
#1. --	#1. Study the information sheets.
#2. --	#2. Check with your instructor for assigned vehicle.
#3. --	#3. Locate needed reference material.
#4. --	#4. Remove check and reinstall a fuse.
#5. --	#5. Remove and install a flasher unit.
#6. --	#6. Complete worksheet #1 and worksheet #2.
#7. --	#7. Turn worksheets in to your instructor.
#8. Ch. 4, p. 86-103	

Electrical Competencies- Body & Chassis

No. F-2 Locate and Replace Commonly Serviced Electrical Components

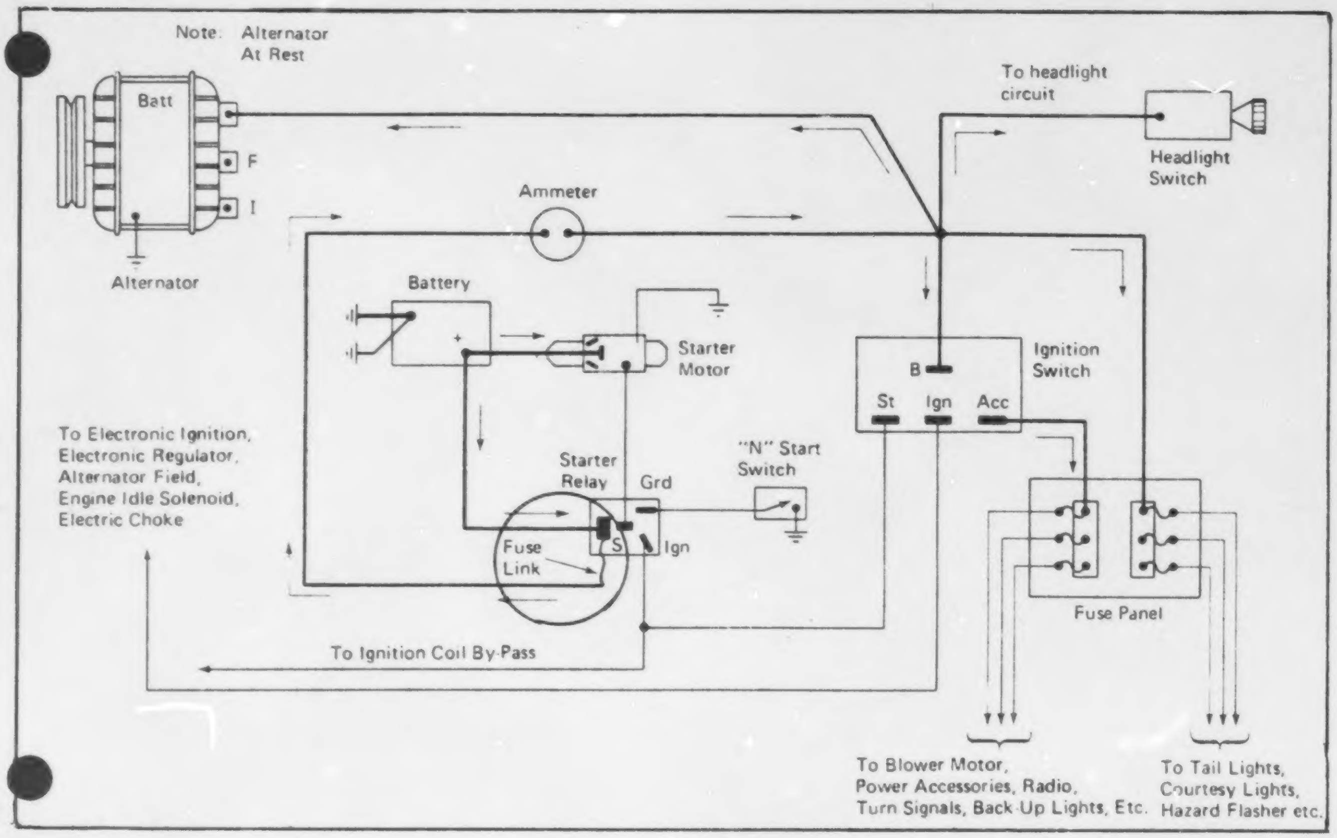
Information Sheet #1

Power Distribution

All major auto electrical circuits are interrelated because they must tap into the power supply of the battery and the charging system.

A typical wiring diagram (brief form) below illustrates the power distribution circuit to various components and accessories. Note that all circuit power flows through a fuse link (circle) and an ammeter (not standard on all vehicles). At the first junction point, the headlights, the ignition switch, and one buss bar on the fuse panel take a direct power feed. The remaining exterior and interior lighting of the car, e.g. the hazard warning, stoplight, taillight, and courtesy light circuits- get their direct power feed from the fuse panel. These circuits and the headlight circuit will have direct power at all times.

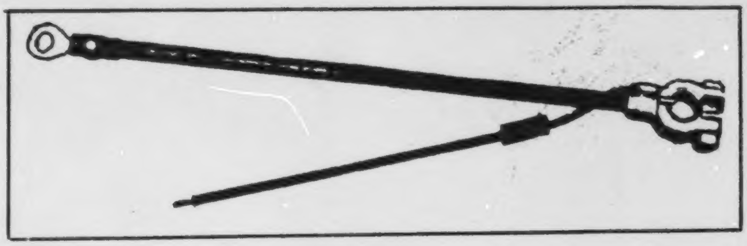
For all accessory circuits and some of the car lighting, the fuse panel (left buss bar) gets a second power feed from the ignition switch accessory terminal. Typical circuits which gain power in this manner include the instruments and indicator lights, directional signal lights, back-up lights,heater blower, windshield wipers, radio, power windows, power seat, cruise control, etc. These circuits will have power only when the ignition switch is either in the accessory or ignition "on" position.


Note: Alternator At Rest
Batt
F
I
Alternator
Ammeter
To headlight circuit
Headlight Switch
Battery
Starter Motor
Ignition Switch
B
St
Ign
Acc
To Electronic Ignition, Electronic Regulator, Alternator Field, Engine Idle Solenoid, Electric Choke
Starter Relay
Grd
"N" Start Switch
Fuse Link
S
Ign
Fuse Panel
To Ignition Coil By-Pass
To Blower Motor, Power Accessories, Radio, Turn Signals, Back-Up Lights, Etc.
To Tail Lights, Courtesy Lights, Hazard Flasher etc.

Circuit Protection

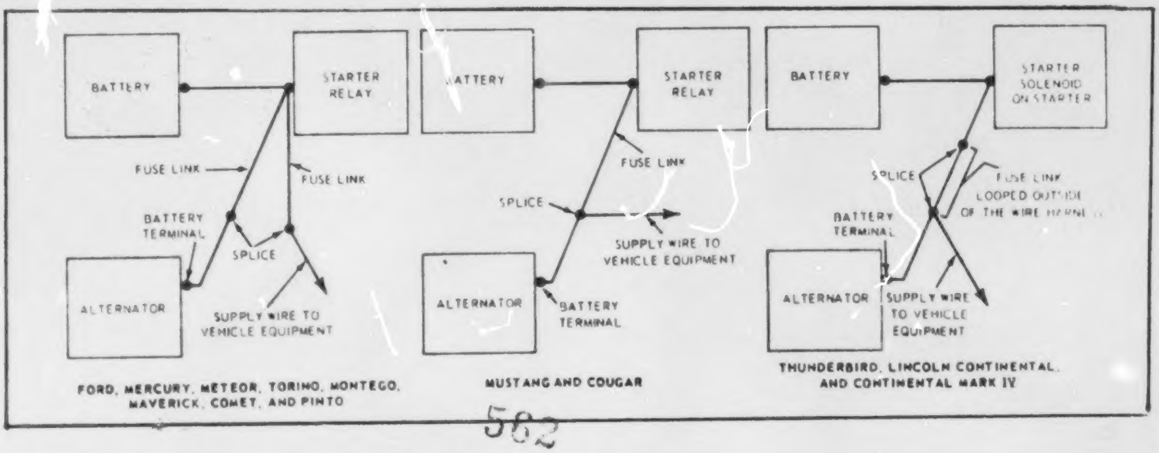
All the circuits mentioned above utilize individual circuit protection devices, either fuses or circuit breakers. (See Electrical Fundamentals, Competency A-5, Information Sheet #3). Because of these individual protection devices, the power distribution circuit is less likely to suffer from the effects of a short circuit. A short circuit, however, can occur especially if improper servicing techniques are used. To protect the entire wiring harness from burning up, all manufacturers use a fusable link near the main battery feed terminal. The fusible link is a short section of wire in series and typically four gauges smaller than the circuit wiring it is protecting.

The figure below shows a fuse link design incorporated into the insulated battery cable.



When a short circuit occurs, the heat generated by the excessive current will cause the fusible link to heat up and melt resulting in an open and therby protecting the curcuit. The insulation on the fuse link is designed to withstand the high melting temperature of the wire. The insulation, however, swells and gives a bubble effect on its surface, indicating that the fusible link has burned out. In some cases, fuse links have been known to melt and not affect the insulation. In these situations, only a conintuity test will indicate its condition.

Fusible link applications vary from manufacturer to manufacturer. Some use several fuse links typically located in the battery cable, on the main power junction block or off the starter relay battery terminal. The illustration below shows some typical Ford applications.


BATTERY
STARTER RELAY
FUSE LINK
FUSE LINK
BATTERY TERMINAL
SPLICE
ALTERNATOR
SUPPLY WIRE TO VEHICLE EQUIPMENT
BATTERY
STARTER RELAY
FUSE LINK
SPLICE
SUPPLY WIRE TO VEHICLE EQUIPMENT
ALTERNATOR
BATTERY TERMINAL
BATTERY
STARTER SOLENOID ON STARTER
SPLICE
FUSE LINK LOOPED OUTSIDE OF THE WIRE HARNE...
BATTERY TERMINAL
ALTERNATOR
SUPPLY WIRE TO VEHICLE EQUIPMENT

FORD, MERCURY, METEOR, TORINO, MONTEGO, MAVERICK, COMET, AND PINTO

MUSTANG AND COUGAR

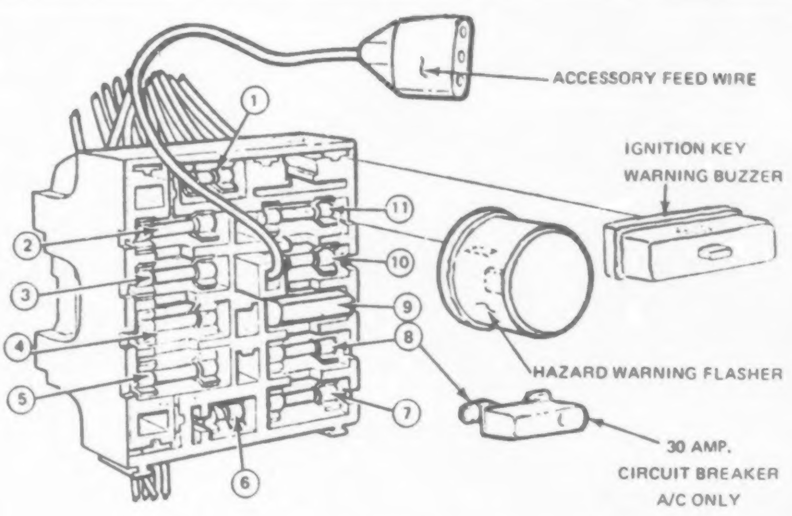
THUNDERBIRD, LINCOLN CONTINENTAL, AND CONTINENTAL MARK IV

No. F-2 Locate and Replace Commonly Serviced
Electrical Components

As indicated previously, most fuse link failures can be traced to improper servicing techniques. Always remember to disconnect the battery when removing any components, electrical or mechanical, within the engine compartment or near the instrument panel. Never use a jumper wire to bypass a circuit protection device. When repairing a fuse link that has failed, always use the repair kit supplied by the manufacturer. The use of the wrong type of wire (with the wrong insultion) could result in a fire if the fuse link were to be activated again. Competency A-5 shows how to replace a fusible link.

The Fuse Panel

A fuse panel or fuse block is a housing that distributes electrical power to the various lighting and accessory circuits. This distribution is provided with circuit protection against electrical shorts by fuses and circuit breaders located and housed in the front side of the fuse panel. For automotive circuits, the fuse panel serves the same purpose as the electrical service entrance panel in your home. The following illustrations show typical fuse panels from Ford, Chrysler, and General Motors.

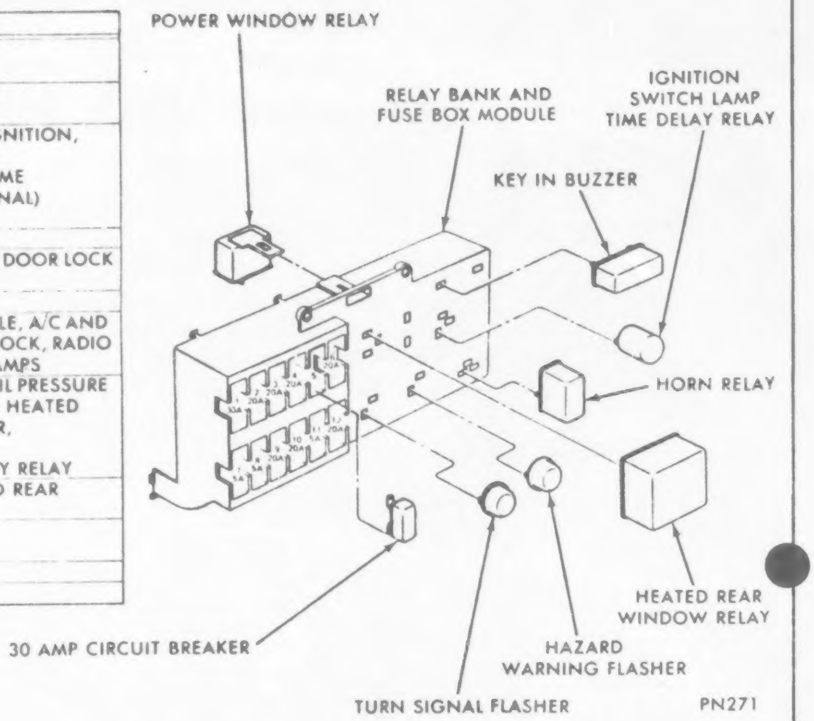


Courtesy of Ford Customer Service Division.

1	(7.5 AMP. FUSE)	INDICATOR LAMPS – ENGINE HOT, OIL PRESSURE, DUAL BRAKE, ALTERNATOR INDICATOR, SEAT BELT, AND PARKING BRAKE
2	(15 AMP. FUSE)	CIGAR LIGHTER
3	(15 AMP. FUSE)	HAZARD WARNING SYSTEM AND STOP LAMPS
4	(15 AMP. FUSE)	COURTESY LAMPS, INSTRUMENT PANEL, R.H. AND L.H. DOORS, DOME, GLOVE BOX, CARGO (STATION WAGON ONLY), LUGGAGE COMPARTMENT, CLOCK FEED, DOOR LOCK SOLENOID, KEY WARNING BUZZER AND SEAT BACK LATCH RELAY CONTROL

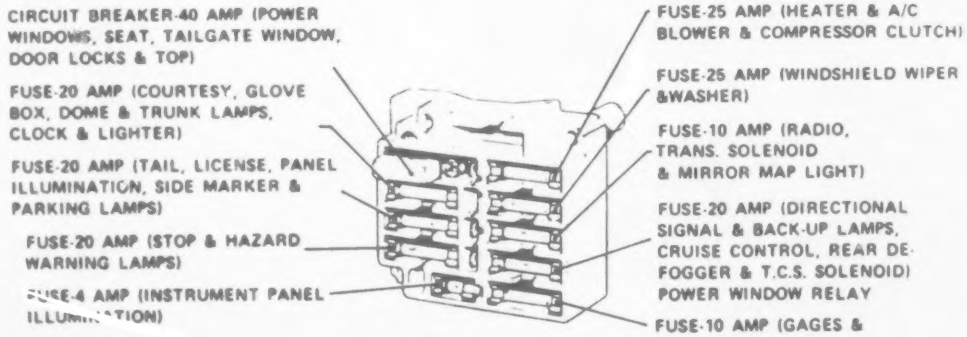
No. F-2 Locate and Replace Commonly Serviced Electrical Components

CAVITY	FUSE	ITEMS FUSED
1.	30 AMP	A/C BLOWER MOTOR AND HEATER BLOWER MOTOR
2.	20 AMP	PARK, TAIL, LICENSE, SIDE MARKER AND INSTRUMENT PANEL LAMPS
3.	20 AMP	STOP, DOME, MAP, GLOVE BOX, IGNITION, UNDER HOOD AND TRUNK LAMPS; KEY-IN BUZZER, IGNITION LAMP TIME DELAY RELAY, CLOCK (CONVENTIONAL) AND CIGAR LIGHTER
4.	20 AMP	HORN (DUAL) AND HORN RELAY
5.	30 AMP C/BRKR.	POWER WINDOW MOTORS, POWER DOOR LOCK SOLENOID AND POWER SEATS
6.	20 AMP	POWER DOOR LOCK RELAY
7.	5 AMP	ASH TRAY, GEAR SELECTOR, CONSOLE, A/C AND HEATER CONTROL, INSTRUMENT, CLOCK, RADIO (AM-FM-MPX) AND SWITCH TITLE LAMPS
8.	5 AMP	SEAT BELT, BRAKE WARNING AND OIL PRESSURE LAMPS; WINDOW LIFT SAFETY AND HEATED BACKLITE RELAYS; VOLTAGE LIMITER, FUEL AND TEMP GAUGE. SEAT BELT BUZZER AND TIME DELAY RELAY
9.	20 AMP	A/C CLUTCH, SPEED CONTROL AND REAR WINDOW DEFOGGER
10.	20 AMP	TURN SIGNAL, BACK-UP AND REVERSE GEAR LAMPS
11.	5 AMP	RADIO
12.	20 AMP	HAZARD FLASHER


POWER WINDOW RELAY
RELAY BANK AND FUSE BOX MODULE
IGNITION SWITCH LAMP TIME DELAY RELAY
KEY IN BUZZER
HORN RELAY
HEATED REAR WINDOW RELAY
30 AMP CIRCUIT BREAKER
HAZARD WARNING FLASHER
TURN SIGNAL FLASHER
PN271

Fuses, Fuse Box, and Relay Bank (H-N Models)

Chart 4-1
Typical G.M. Fuse Specifications*


CIRCUIT BREAKER-40 AMP (POWER WINDOWS, SEAT, TAILGATE WINDOW, DOOR LOCKS & TOP)
FUSE-20 AMP (COURTESY, GLOVE BOX, DOME & TRUNK LAMPS, CLOCK & LIGHTER)
FUSE-20 AMP (TAIL, LICENSE, PANEL ILLUMINATION, SIDE MARKER & PARKING LAMPS)
FUSE-20 AMP (STOP & HAZARD WARNING LAMPS)
FUSE-4 AMP (INSTRUMENT PANEL ILLUMINATION)
FUSE-25 AMP (HEATER & A/C BLOWER & COMPRESSOR CLUTCH)
FUSE-25 AMP (WINDSHIELD WIPER &WASHER)
FUSE-10 AMP (RADIO, TRANS. SOLENOID & MIRROR MAP LIGHT)
FUSE-20 AMP (DIRECTIONAL SIGNAL & BACK-UP LAMPS, CRUISE CONTROL, REAR DEFOGGER & T.C.S. SOLENOID) POWER WINDOW RELAY
FUSE-10 AMP (GAGES & INDICATOR LAMPS)

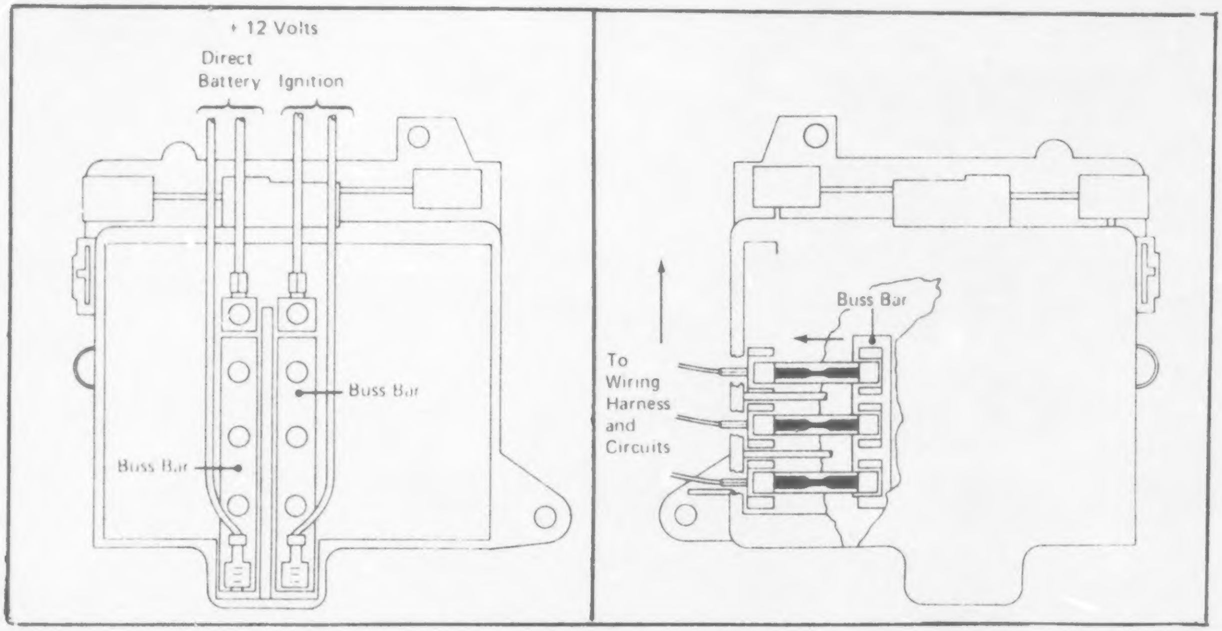
*Courtesy of Buick Division of General Motors Corp.

Additional Component Location

In reviewing the different panel illustrations, note the various pieces of hardware that might be electrically plugged into or attached to the circuits. It is not uncommon to find that a horn relay, ignition key buzzer, hazard flasher, or directional flasher is plugged into the fuse panal.

Fuse Panel Construction

The illustrations below show a back and front view of a fuse panel. On the back side of the panel are two or more 12 volt power leads coming directly from the battery source or from the accessory terminal of the ignition switch. The power leads are attached to a bus bar.



The bus bar is a solid metal strip which distributes power to any number of circuits that are connected to it. In automotive applications, fuse holder clips are riveted to the bus bars. The power input then comes across the individual fuses, as viewed from the front of the fuse panel, for circuit distribution.

For most of the circuits served by the panel, the wire leads are connected to the fuse outlet clips from the back side of the panel. These wire leads are then grouped into the main body wire harness. In some panels, the fuse clips may not be tied to the bus bar since some fuses are built into the panel with their own individual power feeds. The front of the fuse panel may also include cavities for accessory harness connections.

Fuse Application Charts

Each of the circuits leading from the fuse panel is either labeled or number coded at the fuse or breaker insert cavity. Since a fuse usually protects more than one circuit, consult the service manual or car owner's manual to get complete details of all the electrical loads related to each fuse. This information is illustrated with the fuse panels shown. The chart below is found in an owner's manual.

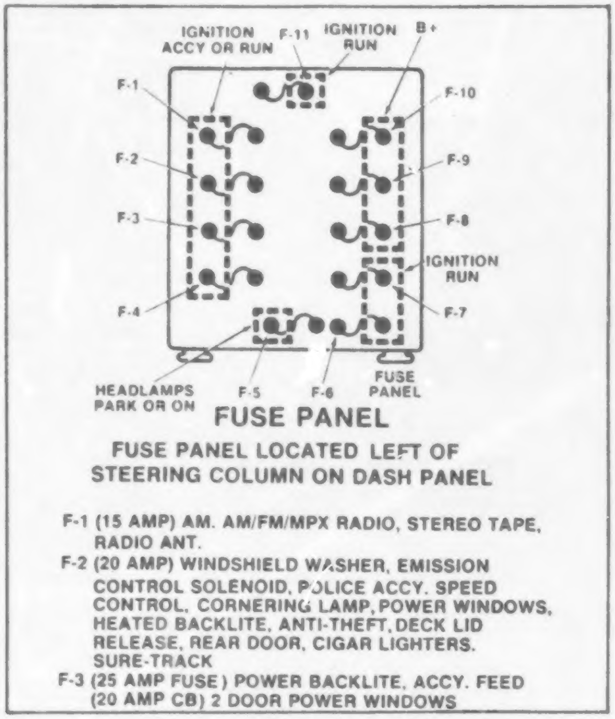
FUSES

FUSES AND THE CIRCUITS THEY PROTECT	Ampere Rating	Length in Inches
BACK-UP, DIRECTIONAL SIGNAL and Signal Indicator Lights, Rear Window Defroster	20	1¼
CIGAR LIGHTERS, Dome and Trunk Lights	20	1¼
CIRCUIT BREAKER for Power Windows, Vents, Top & Seat	40	1¼
CLOCK, COURTESY LIGHTS, GLOVE BOX LIGHT, Power Antenna	20	1¼
HEATER-AIR CONDITIONER Blower and Compressor Clutch	25	1¼
PANEL LIGHTS	4	1¼
PARKING BRAKE, BUZZER OR CRUISE CONTROL, CLUSTER Lights (Oil, Generator, Hot and Cold), Fuel Gauge	7½	1¼
RADIO and Dial Light, Power Window Relay	7½	1¼
STOP, HAZARD FLASHER and Indicator Lights	20	1¼
TAIL, License and Cornering Lights, Panel Lights and Rheostat	20	1¼
WIPER and Washer Motor, Transmission Solenoids	25	1¼
Headlights and Front Parking Lights - Circuit Breaker in Light Switch	15	—

Do Not Use Fuses Of Higher Amperage Rating Than Those Specified Above.

Fuse Data For Diagnosis

By referring to fuse data the technician will have complete knowledge of all circuits connected to any one fuse. This is especially helpful when diagnosing a short circuit. For example, on some vehicles, the clock ties in with the courtesy light circuit. If the clock develops a short, it will then blow the courtesy light fuse. If you do not know that the clock ties in with the courtesy light system, you may spend excessive time trying to locate a nonexistant short in the courtesy lights. Date for fuse panels and their circuits is also presented in wiring diagrams. Below is an example of Ford's diagram of a fuse panel. Note that the information also supplies the panel location in the vehicle. This may not be the case for some types of wiring diagrams. The heavy dashed lines indicate the position of the bus bars.


IGNITION ACCY OR RUN
F-11
IGNITION RUN
B+
F-1
F-10
F-2
F-9
F-3
F-8
IGNITION RUN
F-4
F-7
HEADLAMPS PARK OR ON
F-5
F-6
FUSE PANEL

FUSE PANEL

FUSE PANEL LOCATED LEFT OF STEERING COLUMN ON DASH PANEL

F-1 (15 AMP) AM. AM/FM/MPX RADIO, STEREO TAPE, RADIO ANT.
F-2 (20 AMP) WINDSHIELD WASHER, EMISSION CONTROL SOLENOID, POLICE ACCY. SPEED CONTROL, CORNERING LAMP, POWER WINDOWS, HEATED BACKLITE, ANTI-THEFT, DECK LID RELEASE, REAR DOOR, CIGAR LIGHTERS. SURE-TRACK
F-3 (25 AMP FUSE) POWER BACKLITE, ACCY. FEED (20 AMP CB) 2 DOOR POWER WINDOWS

FUSE PANEL DIAGRAM

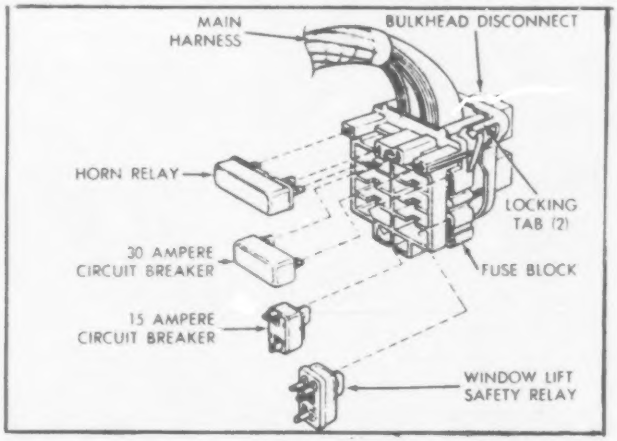
Fuse Panel Location

The fuse panels have several locations on American passenger cars:

1. On the dash firewall inside the car to the left of the brake pedal support.
2. Under the dash to the right side of the steering column support.
3. Back of the dash on left side.
4. Behind right or left kick pad.

On some 1974 models, a swing down fuse panel was introduced. This feature facilitates the checking of fuses.

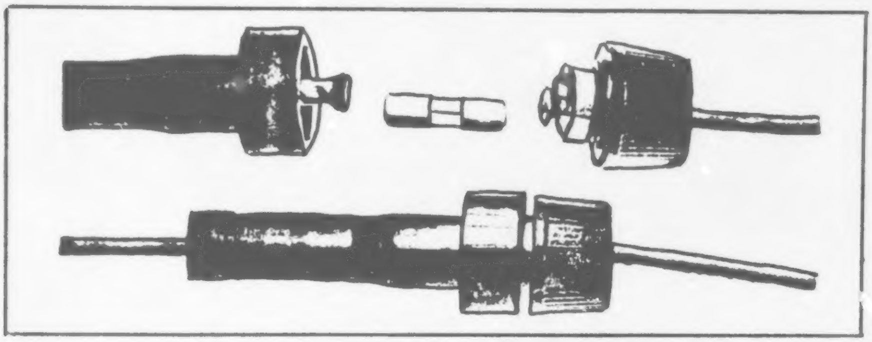
A clue to panel location may be the location of the bulkhead disconnect on the engine side of the firewall. This unit is a multiple wire connector containing the entire front end harness. Many fuse panel types lock into the bulkhead disconnect when installed on the inside of the firewall. See illustration below.


MAIN HARNESS
BULKHEAD DISCONNECT
HORN RELAY
LOCKING TAB (2)
30 AMPERE CIRCUIT BREAKER
FUSE BLOCK
15 AMPERE CIRCUIT BREAKER
WINDOW LIFT SAFETY RELAY

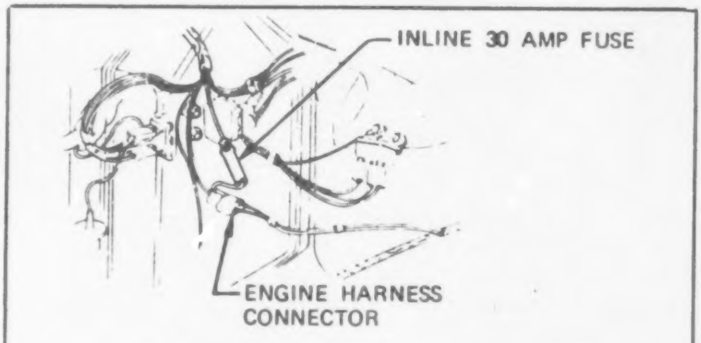
No. F-2 Locate and Replace Commonly Serviced
Electrical Components

Inline Fuses and Fuse Holders

Occasionally a single electrical accessory circuit line by-passes the fuse panel and taps an already existing hot line somewhere in the wiring system, usually at a connector. For circuit protections, an inline fuse is used.



Inline fuses may be difficult to find because they are sometimes located in hidden places- e.g. under the dash. To locate such fuses you may have to consult the manufacturers service manual (see figure below) or a wiring diagram. Competency F-7 covers the interpretation of wiring diagrams.



(Courtesy of Oldsmobile Division of General Motors Corp.)

Fuse Replacement

WHen replacing fuses, several precautions should be noticed. These include:

1. Always replace a fuse with one of the proper amperage rating. A greater amperage fuse may cause wires to burn out, while a lesser amperage fuse will fail and need frequent replacement.
2. Always consult a fuse chart. The fuse currently installed may not be the correct amperage rating.
3. Always use a special tool or a small stiff piece of wire bent into a hook shape to remove fuses. Do not use a screwdriver to pry the fuse out. This will usually break a glass fuse but more importantly, you could short the fuse panel to ground and destroy the power feed wiring harness or burn out the fusible link.

4. Never try to remove a fuse with your fingers. If the glass breaks you will suffer deep cuts.

Competency A-5, Electrical Fundamentals, Information Sheet #3, provides information on fuses and fuse types including the mini-fuse use on 1977 and later General Motors automobiles.

Locate and Replace Turn Signal and Hazard Warning Flashes

A second more commonly serviced electrical component is the flasher unit for turn signal and hazard warning circuits. As with fuse panel installations, manufacturers have no standard location for flasher units. Many flashers are mounted on a support member under the dash to aid in amplifying its audible signal. If the unit is still operating, it can then be traced by its sound. After the unit has failed, however, other sources of information for location becomes necessary.

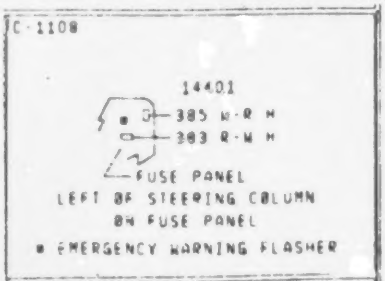
As seen previously, some manufacturers mount the flasher units (one or both) on the fuse panel. In this case locating the fuse panel will solve the problems.

Location Sources

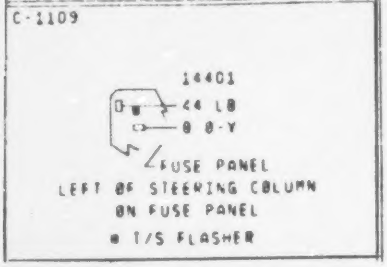
Sources for locating flasher placement include:
1. Car Owner's Manusals (some manufacturers)
2. Manufacturers Service Manuals
3. Motors, Chilton, and Mitchell Manuals
4. Car Wiring Diagrams (Ford and Chrysler)

One of the better sources for locating flasher units is from Motor (see chart on the next pate). The Motor Auto Repair Manual covers application over a seven year span. Manufacturers Service Manuals may provide a pictorial depicting the location of flashers along with other difficult to find components. The rear view of a dash panel (the fourth diagram to follow) is from Chrysler Corporation). Car Wiring diagrams from Ford and Chrysler describe where the flashers are located(below).

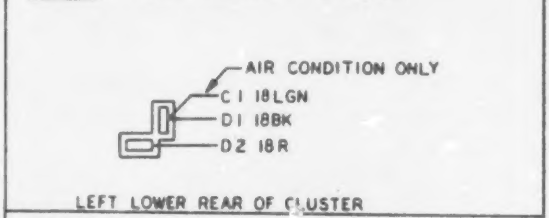
C-1108


14401
385 W-R H
383 R-W H
FUSE PANEL
LEFT OF STEERING COLUMN
ON FUSE PANEL
■ EMERGENCY WARNING FLASHER

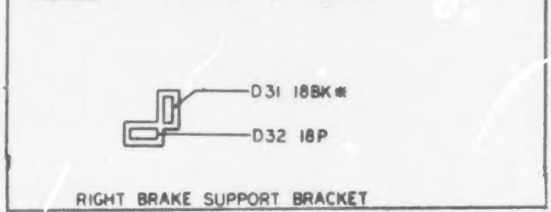
C-1109


14401
44 LB
8 O-Y
FUSE PANEL
LEFT OF STEERING COLUMN
ON FUSE PANEL
■ T/S FLASHER

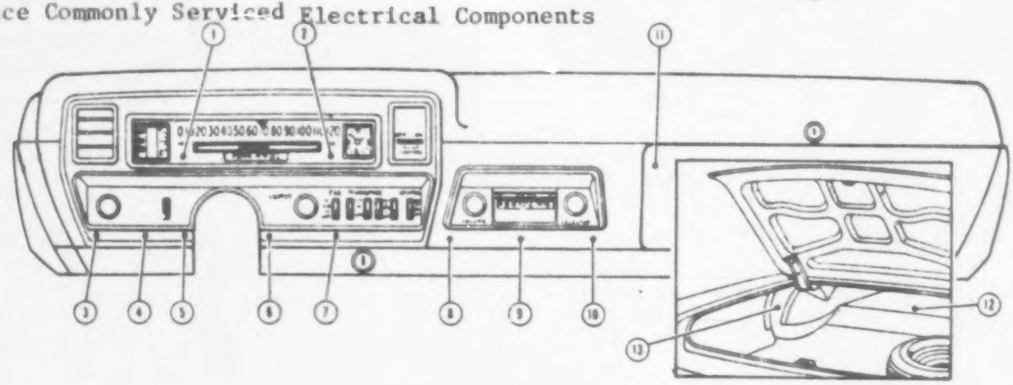
C1 15 TURN SIGNAL FLASHER


AIR CONDITION ONLY
C1 18LGN
D1 18BK
D2 18R
LEFT LOWER REAR OF CLUSTER

C1 16 HAZARD FLASHER


D31 18BK*
D32 18P
RIGHT BRAKE SUPPORT BRACKET

Flasher Locations

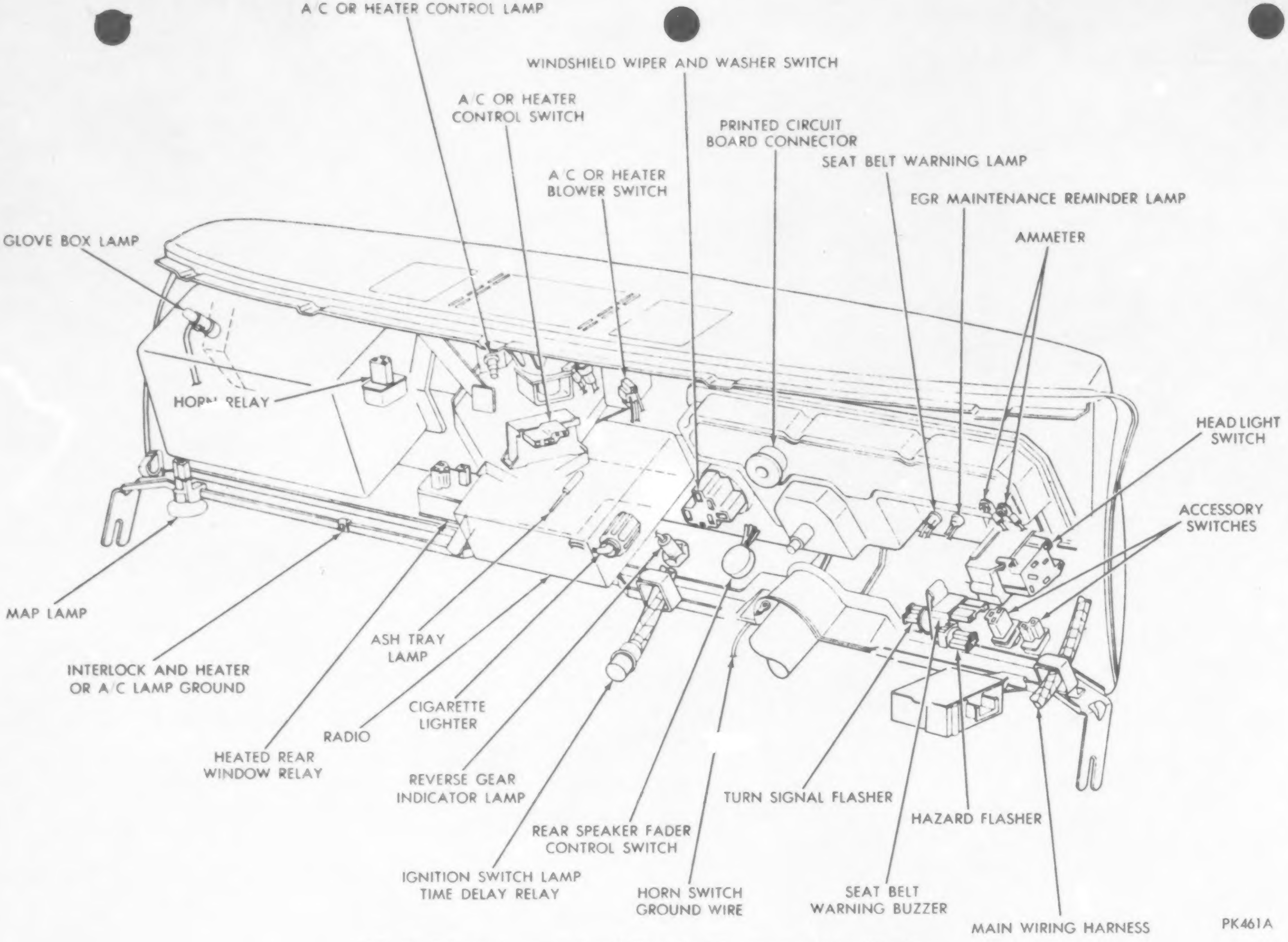


CAR	1968		1969		1970		1971		1972		1973		1974	
	TSF	HWF	TSF	HWF	TSF	HWF	TSF	HWF	TSF	HWF	TSF	HWF	TSF	HWF
American Motors	2	3	2	3	2 ⑭	3	2 ⑯	3	3	3	3	3	3	3
Buick & Special	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Cadillac & Eldorado	5	3	5	5	6	8	⑮	3	⑮	3	⑮	④	⑮	3
Camaro	8	3	8	3	8	3	8	3	8	3	8	3	8	3
Chevelle & Monte Carlo	8	3	8	3	1	3	7	3	7	3	4	3	4	3
Chevrolet	8	3	8	3	10	3	7	3	7	3	6	3	6	3
Chevy II & Nova	8	3	8	3	10	3	7	3	7	3	10	3	10	3
Chevrolet Vega	–	–	–	–	–	–	5	3	5	3	5	3	5	3
Chrysler	8	4	5	4	5	4	5	4	5	5	5	5	⑱	⑲
Comet & Montego	6	5	6	5	6	5	5	5	5	5	5	5	5 ⑳	5 ⑳
Corvair	7	3	7	3	–	–	–	–	–	–	–	–	–	–
Corvette	11	3	⑧	3	⑧	3	⑧	3	⑧	3	⑧	3	⑧	3
Cougar	13	13	8	10	8	10	11	6	8	10	8	10	5	5
Dart & Challenger	6	5	8	5	8	⑨	8	⑨	10	6	8	③	⑱	⑲
Dodge	8	①	⑤	①	5	6	①	–	①	5	8	6	⑱	⑲
Fairlane & Torino	6	5	6	5	6	5	5	5	5	5	5	5	5	5
Falcon & Maverick	6	5	6	⑩	6	⑩	5	5	5	5	6	6	11	11
Ford	1	2	6	5	11	3	8	3	8	3	8	3	3	3
Ford Pinto	–	–	–	–	–	–	10	10	10	10	10	10	11	11
Imperial	8	4	13	13	5	4	5	4	5	5	5	6	⑱	⑲
Lincoln	11	11	11	11	3 ⑫	3 ⑬	6	6	3	3	3	3	7 ④	7 ④
Mercury	4	6	4	6	11	3	8	3	8	3	8	3	3	3
Mustang	1	4	1	4	10	8	11	6	8	10	8	10	11	11
Oldsmobile	1	3	3	3	1	3	4	3	4	3	4	3	4	3
Oldsmobile F-85	3	3	3	3	3	3	4	3	4	3	4	3	4	3
Oldsmobile Toranado	3	3	3	3	4	3	4	3	4	3	4	3	4	3
Plymouth	8	②	⑦	⑥	⑦	6	⑦	–	②	5	8	6	⑱	⑲
Pontiac & Ventura II	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Pontiac Firebird	7	3	3	3	3	3	3	3	3	3	3	3	3	3
Pontiac Tempest, Le Mans	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Thunderbird	13	13	13	13	⑪	11	11	6	3	3	3	3	3	3
Valiant & Barracuda	8	5	8	5	8	6	8	6	10	6	8	⑰	⑱	⑲

TSF: Turn Signal Flasher

HWF: Hazard Warning Flasher

① –Location 10 on Coronet & Charger. Location 5 on Polara & Monaco.
② –Location 10 on Belvedere & Satellite. Location 5 on Fury & VIP.
③ –Location 6 on Challenger. Location 5 on Dart.
④ –Location 3 on Mark IV.
⑤ –Location 4 on Coronet & Charger. Location 8 on Polara & Monaco.
⑥ –Location 6 on Belevedere & Satellite. Location 4 on Fury & VIP.
⑦ –Location 4 on Belvedere & Satellite. Location 6 on Fury & VIP.
⑧ –Extreme lower right corner of instrument panel.
⑨ –Location 6 on Challenger. Location 10 on Dart.
⑩ –Location 5 on Falcon. Behind ash tray on Maverick.
⑪ –To right of glove box.
⑫ –Mark III to right of glove box.
⑬ –Mark III to left of glove box.
⑭ –Location 3 on Hornet and Gremlin.
⑮ –On the underside of steering column lower cover.
⑯ –Location 3 on Hornet, Gremlin and Javelin.
⑰ –Location 6 on Barracuda. Location 5 on Valiant.
⑱ –Behind instrument panel, on right side of ash tray.
⑲ On right side of brake pedal support.
⑳ Location 11 on Comet.


A/C OR HEATER CONTROL LAMP
WINDSHIELD WIPER AND WASHER SWITCH
A/C OR HEATER CONTROL SWITCH
PRINTED CIRCUIT BOARD CONNECTOR
SEAT BELT WARNING LAMP
A/C OR HEATER BLOWER SWITCH
EGR MAINTENANCE REMINDER LAMP
AMMETER
GLOVE BOX LAMP
HORN RELAY
HEAD LIGHT SWITCH
ACCESSORY SWITCHES
MAP LAMP
INTERLOCK AND HEATER OR A/C LAMP GROUND
ASH TRAY LAMP
CIGARETTE LIGHTER
RADIO
HEATED REAR WINDOW RELAY
REVERSE GEAR INDICATOR LAMP
TURN SIGNAL FLASHER
HAZARD FLASHER
REAR SPEAKER FADER CONTROL SWITCH
IGNITION SWITCH LAMP TIME DELAY RELAY
HORN SWITCH GROUND WIRE
SEAT BELT WARNING BUZZER
MAIN WIRING HARNESS
PK461A

(V-L Models) Instrument Panel Electrical Component Identification

Flasher Unit Replacement

Typical flasher units are simple plug in components. Removal and Replacement is self evident upon examination.

Locate and Replace Loads, Switches, Relays, Connectors, and Ground Terminals

As the serviceability requirements of components decrease, so does the generally available information for component locations.

At this point,the manufacturers service manuals provide the best source for component location. A limited coverage of component location can be found in Motor, Chilton, and Mitchell Manuals.

The illustration following, on page 14,from Chrysler Corporation shows specific component location within the engine compartment.

The illustration below from General Motors shows specific component location .

As with signal flasher location, Ford and Chrysler Wiring Diagrams describe the location of loads, switches, relays, connectors, and ground terminals. Competency F-7, covers the interpreting or wiring diagrams.

9B-112 1975 BUICK SERVICE MANUAL

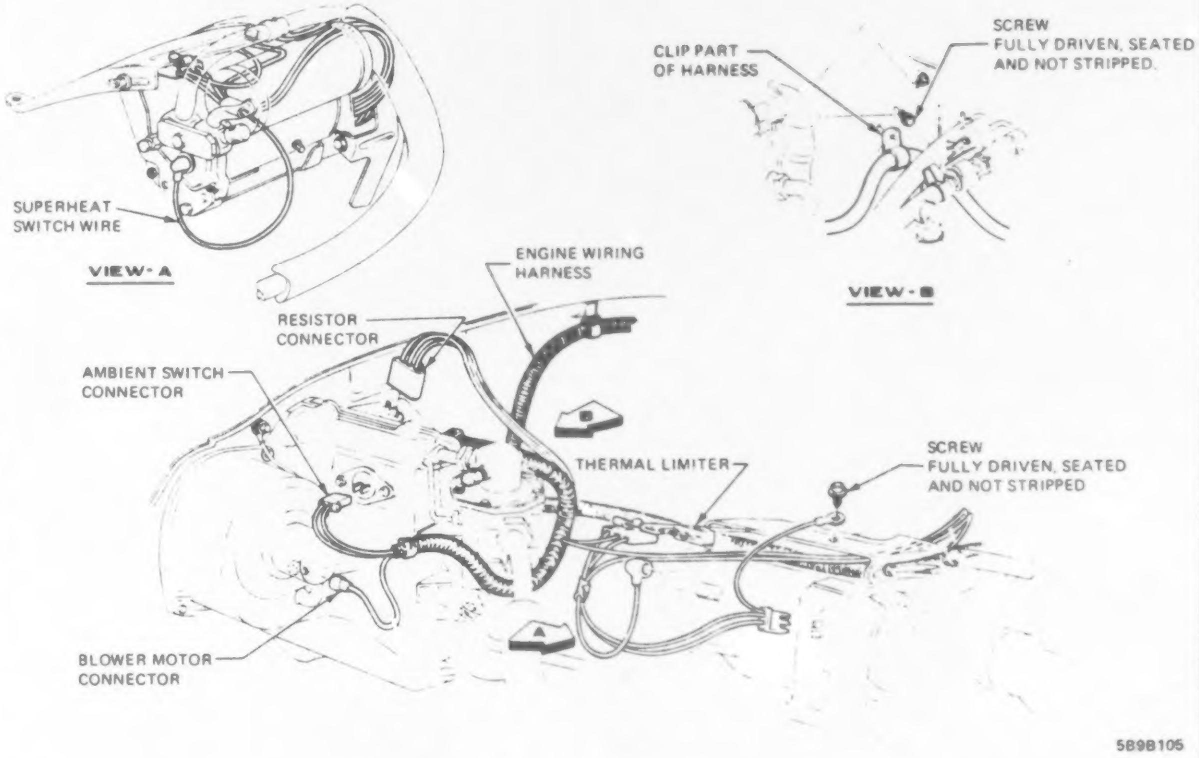
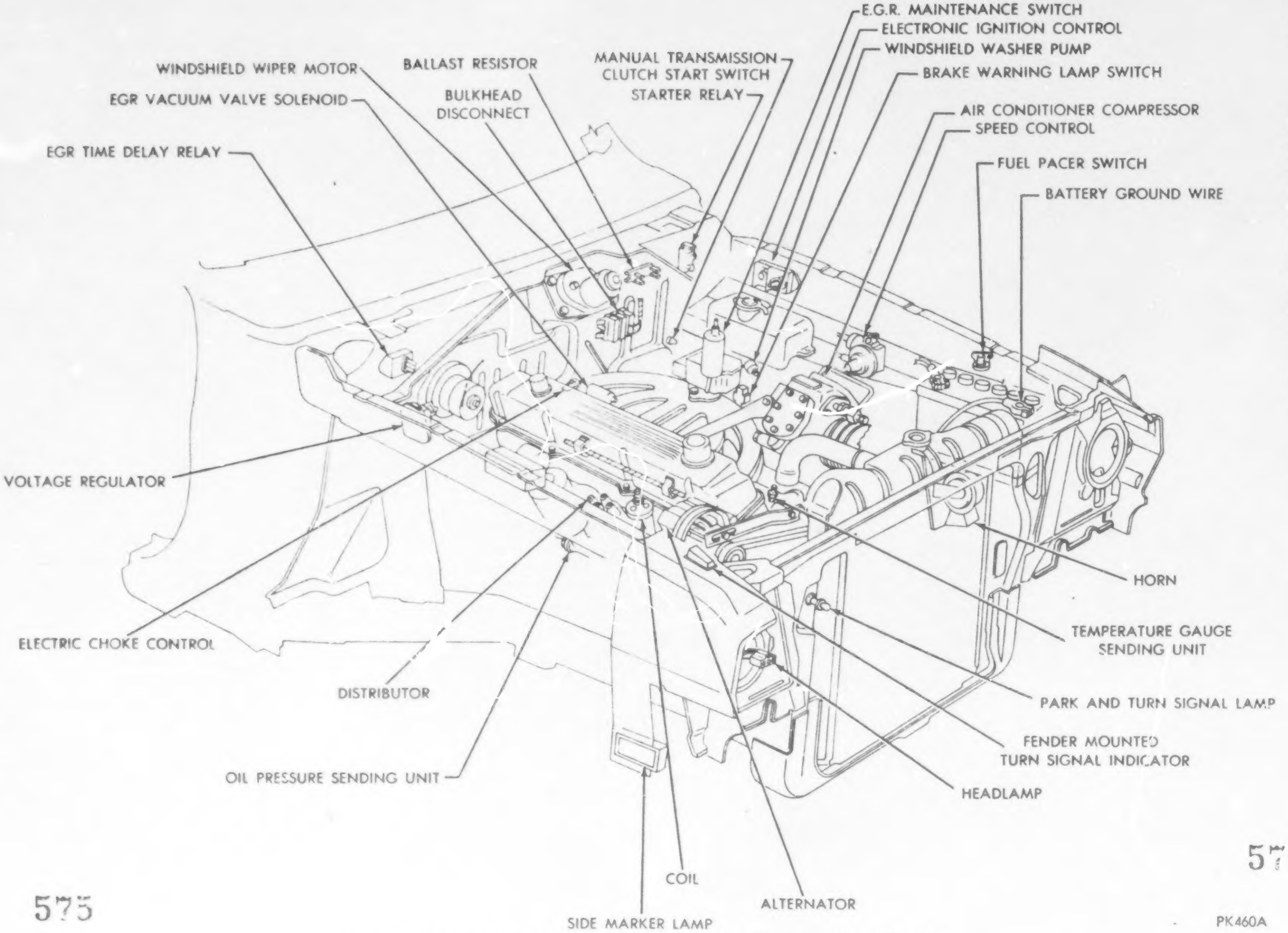

SUPERHEAT SWITCH WIRE
VIEW-A
CLIP PART OF HARNESS
SCREW FULLY DRIVEN, SEATED AND NOT STRIPPED.
VIEW-B
ENGINE WIRING HARNESS
RESISTOR CONNECTOR
AMBIENT SWITCH CONNECTOR
B
THERMAL LIMITER
SCREW FULLY DRIVEN, SEATED AND NOT STRIPPED
A
BLOWER MOTOR CONNECTOR
5B9B105

Figure 9B-227 - Wiring - Manual A/C Blower Motor & Compressor - A Series

Component Replacement

Various component Replacement procedures are detailed in manufacturers repair manuals. More commonly serviced components are also covered in Motors, Chilton, and Mitchell mandeals. Procedures vary from model to model and year to year. (See picture on previous page)


E.G.R. MAINTENANCE SWITCH
ELECTRONIC IGNITION CONTROL
WINDSHIELD WASHER PUMP
BRAKE WARNING LAMP SWITCH
AIR CONDITIONER COMPRESSOR
SPEED CONTROL
FUEL PACER SWITCH
BATTERY GROUND WIRE
WINDSHIELD WIPER MOTOR
BALLAST RESISTOR
MANUAL TRANSMISSION CLUTCH START SWITCH
STARTER RELAY
EGR VACUUM VALVE SOLENOID
BULKHEAD DISCONNECT
EGR TIME DELAY RELAY
VOLTAGE REGULATOR
ELECTRIC CHOKE CONTROL
DISTRIBUTOR
OIL PRESSURE SENDING UNIT
HORN
TEMPERATURE GAUGE SENDING UNIT
PARK AND TURN SIGNAL LAMP
FENDER MOUNTED TURN SIGNAL INDICATOR
HEADLAMP
COIL
ALTERNATOR
SIDE MARKER LAMP
PK460A

(V-L Models) Engine Compartment Electrical Component Identification

Electrical Competencies- Body & Chassis

No. F-2 Locate and Replace Commonly Serviced Electrical Components

Worksheet #1

Name ______________________ Date ________________ Grade __________

Vehicle Make ________________ Year __________

Instructions: Briefly describe the location of the following components on an automobile. Use available location sources if necessary.

Item — Location

1. Fusible Link for main power feed ______________________________

2. Fuse Panel ______________________________

3. Turn signal flasher ______________________________

4. Hazard warning flasher ______________________________

No. F-2 Locate and Replace Commonly Services
Electrical Components

Worksheet #1
Page 2

Item	Location
4. (cont.) Hazard warning flasher	
5. Stop light switch	
6. Back-up light switch	

Instructor's Initials ___________

Electrical Competencies Body & Chassis

No. F-2 Locate and Replace Commonly Serviced Electrical Components

Worksheet #2

Name ______________________ Date __________ Grade __________

Instructions: Remove and Replace the turn signal circuit fuse without damage, following the procedure below. Answer the questions as you go.

1. Locate the turn signal fuse using the label or code on the fuse panel or a fuse panel chart.

a. What is the required amperage rating? __________
b. Does the fuse receive its power from the direct battery feed, or from the accessory terminal feed from the ignition switch? __________

2. Using a proper tool remove the fuse without causing any physical damage. Examine fuse.

a. Is it blown? __________
b. What is the amperage rating? __________
c. What is the fuse type designation? __________
d. Is this the correct fuse for the application? __________

3. Use an ohmmeter or a self powered test light. Test the fuse for continuity?

a. OK? __________ Not OK? __________

4. Have your instructor examine fuse.

a. Instructor check __________

5. Replace fuse without damageing it and check turn signal operation.

a. What is the ignition switch position(s) required to operate? __________
b. System works __________ System doesn't work __________

Instructor's Initials __________

AUTO MECHANICS

Electrical Competencies - Body & Chassis

No. F-3 Lamp Replacement

OBJECTIVE: Upon completion of the foll successfully identify all and replace three of the most common types of bulbs.

EXPLANATION: This will involue a visual diagnosis of faulty lamps along with the correct selection and replacement procedure.

MATERIALS NEEDED: Bulb Application Chart

TOOLS NEEDED: Screw drivers and possibly some of the specialty tools listed on information sheet #1, page 9.

References	Do
#1. --	1. Study the information sheet provided with this package.
#2. Ch. 4, p. 84-85 Ch. 5, p. 105 Ch. 6, p. 121 Ch. 19, p. 398-401	2. Complete worksheet
#3. p. 442-451 p. 464-473 p. 690-708	3. Check with instructor.
#4. p. 291-292 p. 427-436 p. 462-466	
#5. Ch. 32, p. 522-535	
#6. Ch. 34, p. 322-333 Ch. 60, p. 598-610	
#7. Ch. 23, p. 287-297	
#8. Ch. 8, p. 178-217	

Electrical Competencies- Body & Chassis

No. F-3 Lamp Replacement

Information Sheet #1

General Information

Only a few years ago the typical lighting system used in a passenger car consisted only of those lights required by law: headlighs, taillights, and license plate light. In today's car an array of interior and exterior lights have been added for safety and driver convenience. These include: parking lights, stop lights, side-marker lights, back-up lights, dash instrument lights, trunk light, courtesy and dome lights, glove box light, turn signal and hazard warning lights, etc. So it's not uncommon for the lighting system of modern passenger cars today to contain 50 or more lamp bulbs.

When working with lighting circuits, you should be aware of some general facts about light bulbs this will make your service more exact and may even turn you into a salesman. Burned-out bulbs are easy to sell as well as easy to replace.

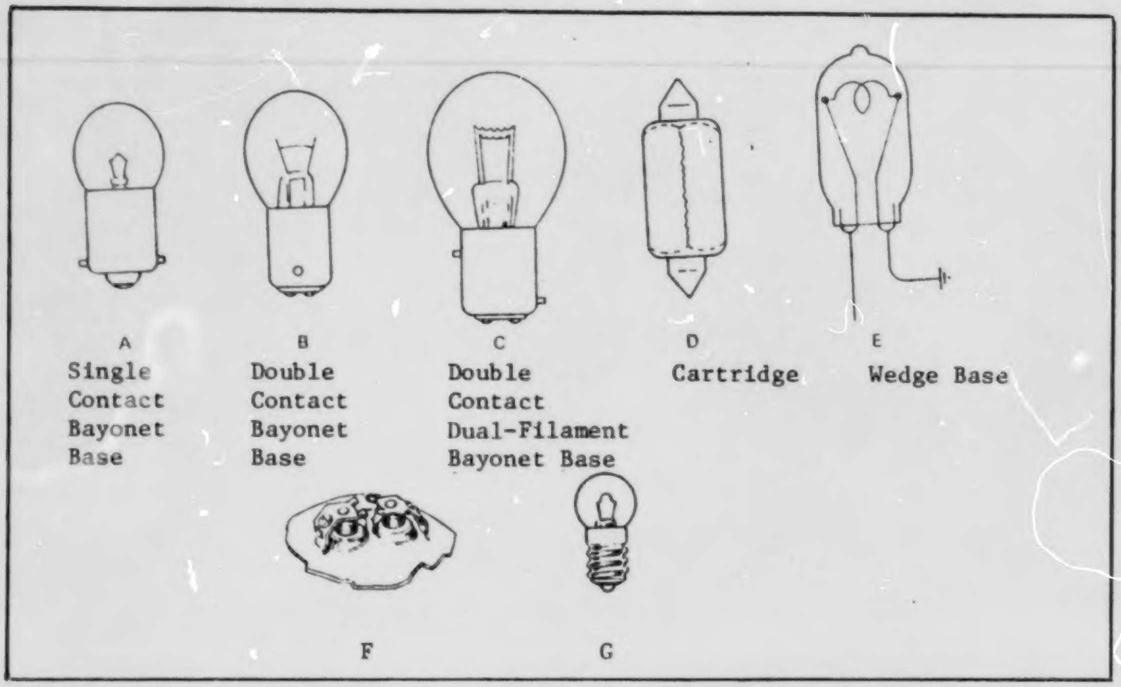
Light bulbs, unlike many other parts and units of a car, have a service life measured in hours of actual use. Rough usage, severe driving conditions,and excessive line voltage shortens the number of service hours that the bulb functions. If the voltage on the bulb is 6 percent higher than normal, bulb life will be reduced by more than 50 percent.

The problem with light bulbs is that they make no noise and produce no "fuss" when they burn out. A car owner is usually not aware that a bulb has burned out in the exterior lighting, and this can affect highway safety. Therfore, every mechanic should always make it a standard practice to give every vehicle he services a safety-light check. The average car owner is usually agreeable to having a bulb replaced, the wiring repaired, terminals cleaned, or a fuse replace. Have you checked your exterior car lighting lately? How do you know that all the light bulbs are functioning?

Small Bulbs

Small bulbs, also known as miniature bulbs, are used for the majority of lights in an automobile (other than headlights, fog lights, and road lights). These smaller type bulbs are available in the following base designs.

Here are some of the most popular types of small bulbs used in passenger cars. "A" is a single contact bayonet base type. The filament is grounded through its socket retainer. This is used in indicator, instrument, license, brake, tailights, turn signals, back-up,and courtesy lights. "B" is a double contact bayonet base type. The base of the bulb is insulated from the filament. The filament is in series to the contacts and is usually grounded at a switch. This is commonly used in courtesy dome, and some parking lights. "C" is a double contact-duel filament bayonet base type. Each filament is in series to one hot contact and the bayonet base ground. This bulb handles two separate circuits and has offset indexing bugs to locate the bulb in its socket properly. It is primarily used in front and rear exterior lighting for stop lights, parking lights, taillights, turn signals, etc. "D" is a cartridge type small bulb which is often used in dome lights and the other areas that require a shallow socket because of limited bulb space. "E" represents the wedge base small bulb in popular use in printed circuit applications and in some side marker lighting. "F" screw terminals are used in some fog and spot lights instead of prong-type connectors. "G" screw base is used in radios- on American made cars. and in instrument panels of some British cars.


A
Single Contact Bayonet Base
B
Double Contact Bayonet Base
C
Double Contact Dual-Filament Bayonet Base
D
Cartridge
E
Wedge Base
F
G

Headlight Bulbs

Headlight bulbs have remained basically the same since the introduction of the sealed beam in 1939. The "safety" legislation of 1940 made sealed-beam headlights a legal requirement in all the states and still regulates current production for both headlights and auxiliary lighting. The few changes that have taken place have been limited to minor modifications in the lens structure and a modest increase in candlepower. For increased visibility, the four-light system on large passenger cars was introduced in 1958.

As most of us realize, car headlights have not produced the optimum illumination necessary for present highway cruising speeds. A car is often moving faster than what the headlights can illuminate. One must realize, however, that car manufacturers have been hindered in their ambition to give better lighting up front. In the 1940's, the use of high-intensity lights was abused by a significant number of car owners so that light intensity and glare became a road safety hazard. Various state legislatures passed laws regulating the power of the headlights, and regulating the number and use of auxiliary lights. In some states auxiliary lights were banned entirely. Because each state has its own regulations, car manufacturers are limited to designing a headlight system that will satisfy all legal requirements.

The U.S. Department of Transportation has recently considered upgrading automobile headlighting systems. They have proposed new regulations permitting an increase in candlepower from the current 7,500 to a maximum 200,000.

Headlights are classified as Type-1 or Type-2. Type-1 bulbs have a single filament centered in the reflector so that the light is reflected straight ahead; they are used as the inboard lights in a four-lamp dual sealed-beam roadlighting system and provide for part of the upper beam pattern in conjunction with the Type-2 bulb located on the outboard.

Type-2 bulbs have double filaments. One filament is slightly above the reflector focal point and the other is slightly below. The upper filament provides the low beam and the lower filament the upper beam. The low beam carries the higher candlepower.

In a four-lamp dual sealed-beam roadlighting system the Type-1 and Type-2 bulbs each have a standard 5 3/4-inch diameter. Both high beam projections from the bulbs are aimed into a single effective up-front pattern for maximum lighting on open-road driving. For traffic driving, a low-beam pattern is furnished by the Type-2 bulb only.

On vehicles using a two-lamp dual sealed-beam roadlighting system, two similar 7-inch Type-2 bulbs are used, one on each side of the vehicle, providing for upper and lower beams.

It is difficult to interchange or mix-up Type-1 and Type-2 5 3/4-inch bulbs during installation for the following reasons:

1. For easy identification, the bulb type number is clearly molded on the top of the front lens.
2. The seating lugs on the back of the reflector flange, are located at different angles for Type-1 and Type-2 bulbs, and will not permit installation of the bulb, in other than their own retainers. These lugs also insure that the bulbs will be set in their correct position within the headlamp assembly.
3. A Type-2 bulb has three terminal connectors and a Type-1 bulb two terminal connectors. One terminal always leads to a chassis ground.

Bulb Application Charts

Because of the many different types of bulbs found in vehicles today, its almost impossible to select the correct bulb for the application without some type of specification table or chart. Bulb selection is a very important item to remember when choosing a replacement unit. You should never expect that the last person to service your lighting system did it correctly, a quick look at a specification table may save you alot of time in the long run.

Bulb application charts can be found in various places, probably the first place to look would be your owners manual under specifications. Another resource could be an electrical service manual put out by the different car manufacturers. If these aren't available the store selling the bulb will usually have an application chart of their own.

Electrical Competencies- Body & Chassis

No. F-3 Lamp Replacement

Information Sheet #1
Page 4

LIGHT BULBS

Location	Bulb No.	Candlepower
Ash Tray	1445	.5
Back-up	1156	32
Brake Warning	194	2
Cornering	1195	50
Courtesy Light (Instrument Panel)	89	6
Courtesy Lights (Console and Rear Seat)	90	6
Cruise Control Indicator	161	1
Dome, Center Roof	1004	15
Glove Box	1893	2
Headlight High Beam Indicator	161	1
Headlight, 5¾" Dia., Type 1 (Inner)	4001	37.5 watts
Headlight, 5¾" Dia., Type 2 (Outer)	4002-L	37.5-55 watts
Heater, Air Conditioner Control Dial	1893	2
Ignition Switch	53	1
Indicator Lights (Hot, Cold, Oil and Amp.)	194	2
Instrument Cluster Dials	194	2
License	97	4
Radio Dial	1892	1
Turn Signal and Parking, Front (Natural Amber)	1157-NA	32-4
Turn Signal, Tail and Stop, Rear	1157	32-4
Turn Signal Indicator	161	1
Trunk	89	6

If difficult, is encountered in replacing a light bulb, your local Buick dealer will be glad to help you

SPECIFICATIONS

LIGHT BULBS

Replace With AC-Guide Lamps

LOCATION	BULB NUMBER
Air Conditioning Control	194
Ash Tray	Fiber Optic
Back-Up Light	1156
Brake Warning Light	194
Cigar Lighter Illumination	1445
Clock	Cluster Illumination
Courtesy	89
Dome Lamp	561
Engine Temperature Telltale	194
Fuel Gage and Voltmeter (Rally)	1895
Generator Telltale	194
Glove Box	1891
Headlamps - Outer (Type 2A)	4652
Headlamps - Inner (Type 1A)	4651
Headlamp High Beam Indicator	194
Heater Control Panel	194
Instrument Cluster Illumination	194
License Plate	194
Luggage Compartment	1003
Marker Lights - Front and Rear	194
Oil Pressure Indicator	194
Parking Lights	1157NA
Radio Illumination	1893
Reading Lamp	1004
Seat Belt Warning	194
Stop Light	1157
Tachometer	Cluster Illumination
Tail Light	1157
Transmission Shift Indicator(Auto) - Console	1445
Turn Signal - Front	1157A
Turn Signal - Rear	1157
Turn Signal - Indicator	194

CHART 8-1

BULB CHART

Bulb Trade Number	Candle Power	Current @ Rated Voltage	Bulb Trade Number	Candle Power	Current @ Rated Voltage
53X	1	.12 Amps	1178	4	.69 Amps
67AF	4	.59 Amps	1195	50	3.00 Amps
90	6	.58 Amps	1196	50	3.00 Amps
90	15	1.04 Amps	1232	4	.59 Amps
97	4	.69 Amps	1445	1.5	.15 Amps
158	2	.24 Amps	1815	1.4	.20 Amps
161	1	.19 Amps	1816	3	.33 Amps
211	12	1.02 Amps	1891	2	.24 Amps
212	6	.74 Amps	1892	1.3	.12 Amps
256	1.6	.27 Amps	1893	2	.33 Amps
257	1.6	.27 Amps	1895	2	.27 Amps
631	6	.63 Amps	4001	26,000	2.93 Amps
1003	15	.94 Amps	4002	21,000 Low 14,000 Hi	3,91,2.93 Amps
1004	15	.94 Amps	4405	50,000	2.34 Amps
1034	32-4	1.80-.51 Amps	4412	35 Watts	2.74 Amps
1073	32	1.80 Amps	4414	18 Watts	1.41 Amps
1076	32	1.80 Amps	4415	35 Watts	2.73 Amps
1095	4	.51 Amps	4416	30 Watts	2.34 Amps
1141	21	1.44 Amps	4435	75,000	2.34 Amps
1142	21	1.34 Amps	4475	30 Watts	2.34 Amps
1155	4	.59 Amps	6012	21,000 Low 32,000 Hi	3.12,3.91 Amps
1156	32	2.10 Amps	6013	21,000 Low 32,000 Hi	3.12,3.91 Amps
1157	32-4	2.10-.59 Amps	6112	21,000 Low 14,0000 Hi	3.91,2.93 Amps

LAMP BULBS—1974 Passenger Cars

Make	Headlamp		Headlamp Beam Indicator	Parking Light	Tail Light	Stop Light	Turn Indicator			License Plate Light	Instrument Light	Side Marker Light	Cornering Light	Dome Light	Clock Light	Radio Dial Light	Glove Compartment Light	Courtesy Light	Trunk Compartment Light	Brake Indicator	Shift Dial Indicator	Oil Tell-Tale	Generator Tell-Tale	Temperature Tell-Tale	Back-up Light	Seat Belt Indicator
	Type 1	Type 2					Front	Rear	Tell-Tale																	
American Motors	①	①	②	1157	1157	1157	1157	1157	③	–	158	④	–	561	⑤	1815	1891	561	89	⑥	⑦	⑥	②	–	1156	–
Buick	⑧	⑧	194	1157NA	1157	1157	1157NA	1157NA	194	194	168	⑨	1295	211	⑩	⑪	1891	⑫	89	⑬	⑭	⑮	⑬	⑮	⑯	⑰
Buick Apollo	6014	–	194	1157	1157	1157	1157	1157	194	67	168	194	1295	211	1893	293	1895	631	1003	161	–	168	161	168	1157	194
Cadillac	5001	4000	161	1157NA	1157	1157	1157NA	1157NA	161	168	1816	⑱	1295	–	53	1895	1816	⑲	1003	168	–	168	161	168	1156	168
Chevelle & Monte Carlo	6014	–	168	⑳	1157	1157	⑳	1157	168	168	168	194	–	211	–	1816	–	631	1003	168	168	168	168	168	1156	168
Chevrolet	5001	4000	194	1157NA	1157	1157	1157NA	1157	194	168	168	194	–	211	–	1816	–	631	1003	194	–	194	194	194	1156	194
Chevy Camaro	6014	–	194	1157NA	1157	1157	1157NA	1157	194	168	194	194	–	211	—	1816	–	㉑	1003	194	–	194	194	194	1156	194
Chevy Nova	6014	–	194	1157	1157	1157	1157	1157	194	67	168	194	–	211	–	293	–	631	1003	194	–	194	194	194	1156	194
Chevy Vega	6014	–	194	㉒	1157	1157	㉒	㉒	194	168	194	194	–	211	–	1816	–	–	–	293	–	194	194	194	1156	194
Corvette	5001	4000	1895	1157NA	1157	1157	1157NA	1157	1895	168	1895	168	–	212	1895	1893	–	631	1895	1895	1895	–	–	–	1156	1895
Chrysler & Imperial	4001	4000	158	1157NA	1157	1157	1157NA	1157	158	168	158	168	1156	211	158	168	1891	211	1003	158	–	158	–	–	1156	158
Comet & Maverick	6014	–	194	1157	1157	1157	1157	1157	194	1178	194	161	–	561	–	1893	1816	–	631	194	–	194	194	194	1076	194
Cougar	4001	4000	194	1157NA	1157	1157	1157NA	1157	194	631	194	194	–	561	194	1893	1816	–	631	194	–	194	–	–	1156	194
Dodge	㉓	㉓	㉔	㉕	1157	1157	㉕	1157	㉔	㉖	㉗	168	–	㉘	–	㉙	1891	89	1004	㉔	㉚	㉛	–	–	1156	㉜
Ford & Mercury	4001	4000	194	㉝	1157	1157	㉞	1157	194	㉟	194	194	1295	561	194	1893	194	㊱	631	194	–	194	194	194	1156	194
Ford Pinto	6014	–	194	1157NA	1157	1157	1157NA	1157	194	631	194	194	–	211	–	1893	1816	–	631	194	1445	–	194	194	1156	194
Lincoln	4001	4000	194	1157NA	168	1157	1157NA	1157	194	168	194	194	1196	–	194	1893	1895	105	631	194	–	–	–	–	1156	194
Mark IV	4001	4000	194	1157NA	1157	1157	1157NA	1157	194	1178	194	194	1196	–	–	1893	194	–	–	194	–	194	–	–	1156	194
Montego & Torino	4001	4000	194	1157NA	1157	1157	1157NA	1157	194	631	194	194	–	561	194	1893	1816	631	631	194	1445	194	–	–	1156	194
Mustang II	6014	–	194	1157NA	1157	1157	1157NA	1156	194	194	194	194	–	211	194	1893	1816	214	631	194	1445	194	–	–	1156	194
Oldsmobile (Exc. Below)	6014	–	161	1157NA	1157	1157	1157NA	1157NA	194	97	168㊲	194	–	211	1816	1893	563	㊳	1003	161	1895	168	168	557	1156	194
Oldsmobile Omega	6014	–	194	1157NA	1157	1157	1157NA	1157	194	67	168	194	–	211	1816	1893	1895	67	1003	194	1895	194	194	194	1156	194
Olds. 88, 98 & Toronado	4001	4002	161	1157NA	1157	1157	1157NA	1157NA	161	97	168	194	1295	211	1816	1893	1891	89	–	194	–	194	168	557	1156	194
Plymouth Barracuda	6014	–	㊴	1157NA	1157	1157	1157NA	1157	㊴	67	㊵	168	–	㊶	–	1816	1891	89	1004	㊴	㊷	57	–	–	1156	–
Plymouth Fury	4001	4000	158	1157NA	1157	1157	1157NA	1157	158	168	158	168	–	211	158	168	1891	90	1003	158	–	158	–	158	1156	158
Plymouth Satellite	4001	4000	㊸	㊹	1157	1157	㊹	1157	㊸	㊺	㊸	168	–	1004	–	1816	1891	562	1004	㊸	㊷	158	–	–	1156	1816
Plymouth Valiant	6014	–	158	1157NA	1157	1157	1157NA	1157	158	168	158	168	–	1004	–	1893	1891	89	1004	158	161	158	–	–	1156	1445
Pontiac (Exc. Below)	6014	–	194	1157NA	1157	1157	1157NA	1157	194	194	㊻	194	1156	211	–	㊼	1891	89	1003	194	㊽	194	–	–	1156	194
Pontiac Ventura	6014	–	194	1157	1157	1157	1157	1157	194	67	168	194	1156	211	–	1893	1891	631	1003	194	–	194	–	–	1157	194
Pontiac (Full Size)	5001	4000	194	1157NA	1157	1157	1157NA	1157	194	194	194	194	1156	211-1	–	1893	1891	89	1003	194	–	194	–	194	1156	194
Pontiac (Grand Prix)	6014	–	194	1157NA	1157	1157	1157NA	1157	194	194	192	194	1295	211-1	–	1893	1891	89	1003	194	–	194	–	194	1156	194
Thunderbird	4001	4000	194	1157NA	168	1157	1157NA	1157	194	1178	631	194	1196	561	–	1893	194	214	631	194	–	194	194	194	1156	194

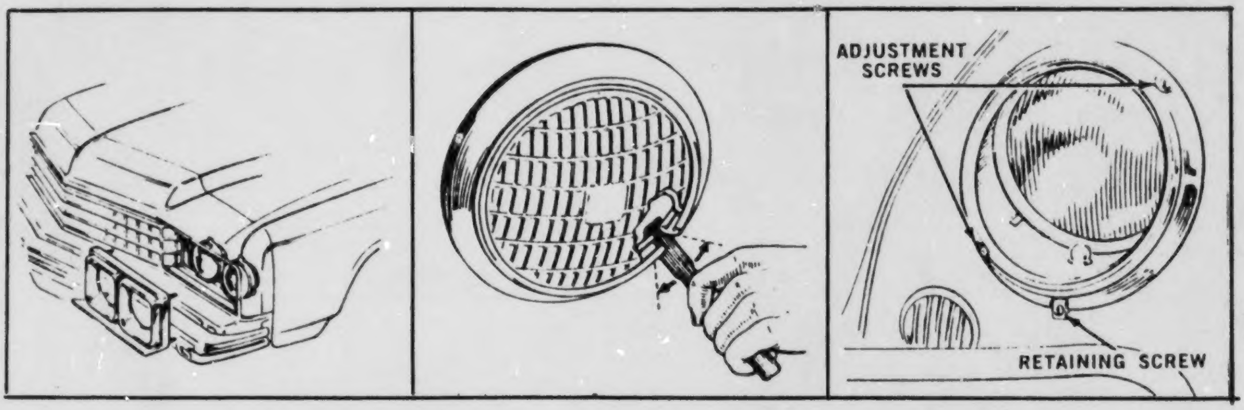
① Single Headlamp #6014; Dual Headlamp Type 1 #5001, Type 2 #4000.
② Exc. Javelin #158; Javelin #53.
③ Matador & Ambassador #158; Gremlin & Hornet #158; Javelin #1891.
④ Exc. Hornet Rear #194; Hornet Rear #1895.
⑤ Exc. Javelin #1895; Javelin #158.
⑥ Exc. Javelin #1891; Javelin #158.
⑦ Std. Column #1816; Adj. Column #1445.
⑧ Int. #6014; Full Size #4001, 4000L.
⑨ Exc. Riviera Front #194; Riviera Front #1157NA.
⑩ Int. #1893; Full Size #1843.
⑪ Int. #1893; Full Size #566.
⑫ Exc. Wag. #212; Wag. #211.
⑬ Int. #161; Full Size #194.
⑭ Riviera Center Console #1816.
⑮ Int. #168; Full Size #194.
⑯ Exc. Wag. #1157; Wag. #1158.
⑰ Int. #194; Full Size #1893.
⑱ Eldorado Front #97A, Rear #194; All Others Front #194A, Rear #194.
⑲ Courtesy Front #90; Courtest Rear #212.
⑳ Monte Carlo & Chevelle (Laguna) #1157NA; Chevelle #1157.
㉑ Front Seat #631; Rear Seat #212.
㉒ Exc. GT #1157; GT #1157NA.
㉓ Exc. Dart #4001, 400; Dart #6014.
㉔ Dart, Monaco, Coronet & Charger #158; Challenger, Coronet (Rallye) #57; Challenger (Rallye) #1895.
㉕ Dart & Monaco #1157NA; Challenger, Coronet & Charger #1157.
㉖ Dart, Coronet, Charger Sta. Wag. & Monaco #168; Challenger, Coronet (Rallye) #67.
㉗ Dart & Monaco #158; Challenger #1816; Challenger (Rallye) #1893; Coronet & Charger #57 or #158.
㉘ Dart, Coronet & Charger #1004; Challenger & Monaco #211; Challenger (Rallye) #551.
㉙ Exc. Monaco #1816; Monaco #168.
㉚ Column Shift #161; Console Shift #57.
㉛ Exc. Monaco #158; Monaco #57.
㉜ Challenger #1445; Coronet & Charger #1816; Monaco #158.
㉝ Ford Front #97A, Rear #194, Mercury #1157NA.
㉞ Ford #1157; Mercury #1157NA.
㉟ Exc. Sta. Wag. #90; Sta. Wag. #1178.
㊱ Ford #631; Mercury #105.
㊲ Fuel Gauge Cluster Top #194; Bottom #161
㊳ Front #89; Console #97.
㊴ Exc. Rallye #57; Rallye #1895.
㊵ Exc. Rallye #1816; Rallye #1893.
㊶ #211-1, #551 or #1004.
㊷ Column Shift #161; Console Shift #57.
㊸ Exc. Rallye #158; Rallye #57.
㊹ Exc. Rallye #1157; Rallye #1157NA.
㊺ Exc. Rallye #67; Rallye #168.
㊻ LeMans #168; All Others #194.
㊼ Exc. Firebird #1893; Firebird #1895.
㊽ Exc. Firebird, Fiber Optic, Firebird #1445

Headlamp Removal and Replacement

Several types of retaining rims are in use; most have Phillips-head screws holding rim to lamp shell, fender, or grille.

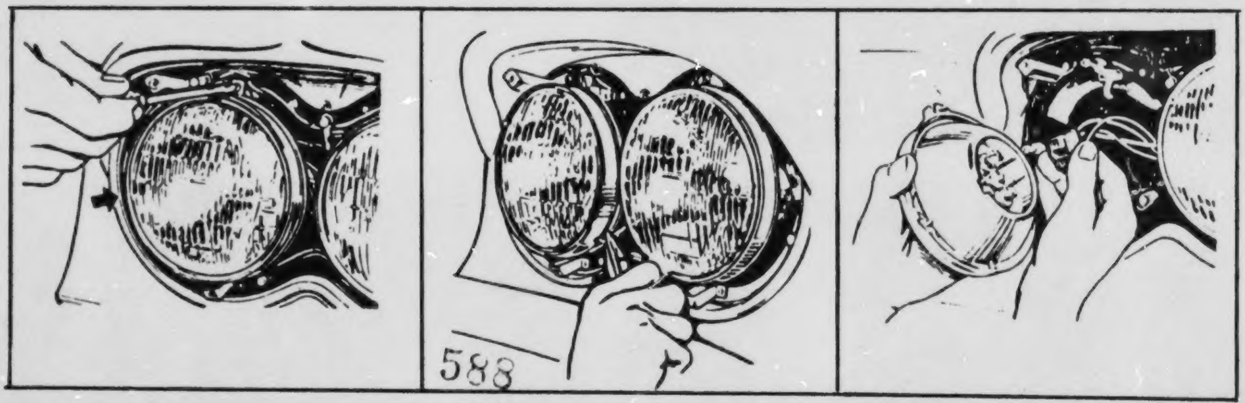
Some imported cars have rims held by clips only (identification is easy because no screws can be seen); and L-shaped piece of metal inserted behind rim and twisted will force rim off car.

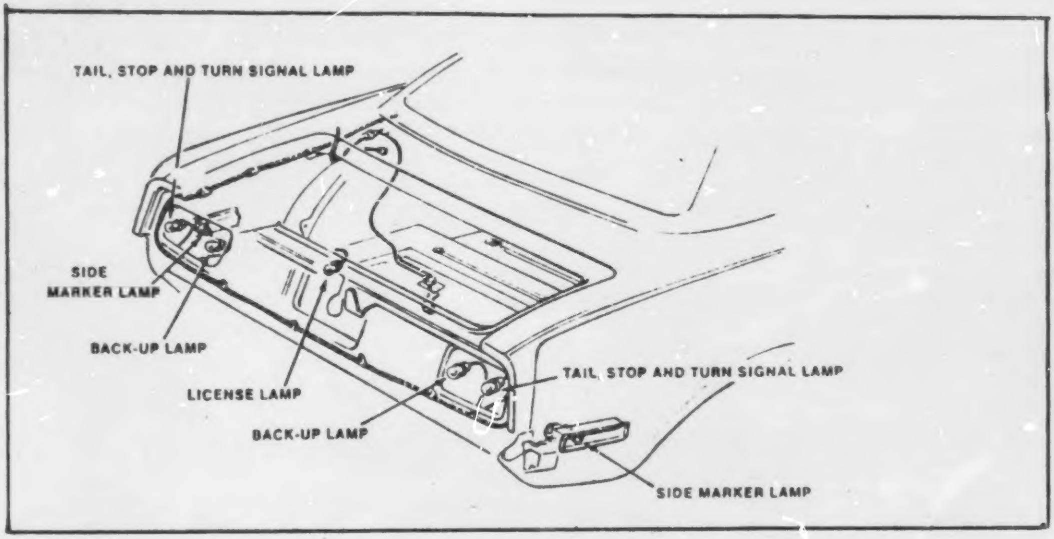
Some Chrysler models and some imported cars (VW, Porsche, some Jaguar and Mercedes, etc.) have glass cover over sealed-beam unit; take care not to break glass when unscrewing retaining rim.



On all cars, sealed-beam unit is held firmly against lamp shell by a bulb retaining ring which has:

- Two or three retaining screws,
- Two or three aiming screws. Before loosening any screws, identify those used for headlight aiming. DO NOT disturb aiming screws. Loosen, but do not remove, the two or three retaining screws; turn retaining ring slightly, and remove ring. (Some cars also have small springs holding the ring. Unhook springs using long-nose pliers). Remove sealed-beam unit and pull connector from prongs.
-Installation of new sealed-beam unit follows reverse order of removal instructions after terminal has been inspected for corrosion and cleaned, if necessary. Also, replace any damaged gaskets or seals.



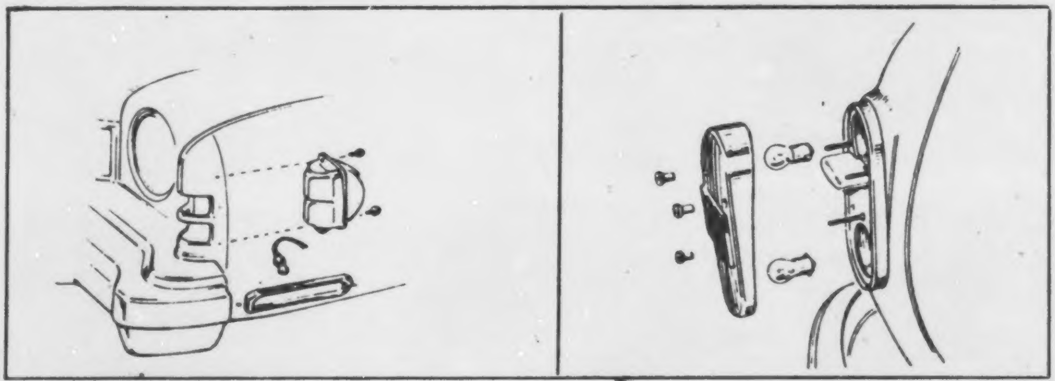


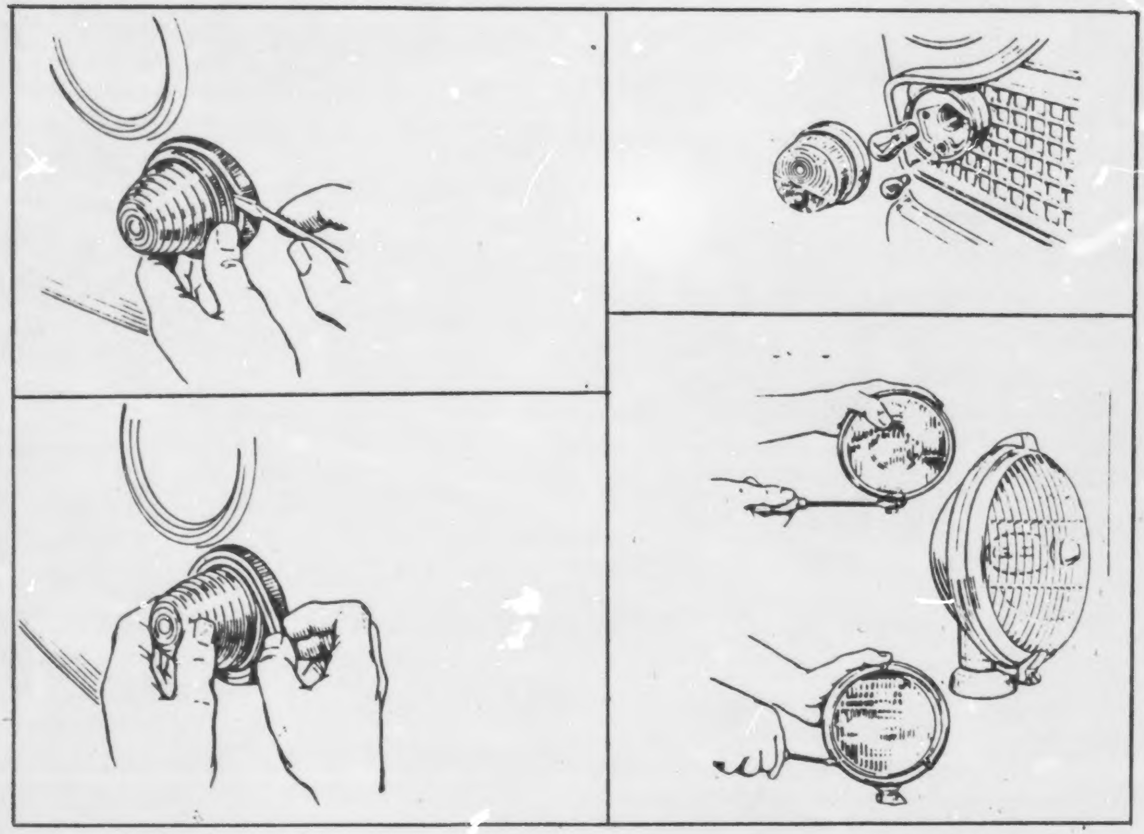
Safety Courtesy and Accessory

Parking, turn signal, cornering, side marker, brake, and taillights are frequently easy to replace. Many of the rear end lights are accessible through the trunk. Simply pull the lamp and socket assembly from its holder and remove the bulb from its socket. Some installations require the removal ov the lamp lens or lamp housing. In any event, an examination of the lamp and socket will indicated if the bulb is removed by being pulled straight out or by being twisted to relieve the indexing lugs.

An inspection of side marker light installation will quickly reveal if the bulb can be removed by disengaging its socket from under the fender, under the hood, or through the trunk or if its lens retaining screws must be removed. In a few instances the lamp housing must be removed from the fender to permit bulb replacement.
NOTE: When providing lighting system service, it is advisable to disconnect the battery ground cable until all bulbs are replaced and sockets are repositioned.

Some imported cars retain the lens with a double-lip rubber seal holding both lens and chrome trim ring.



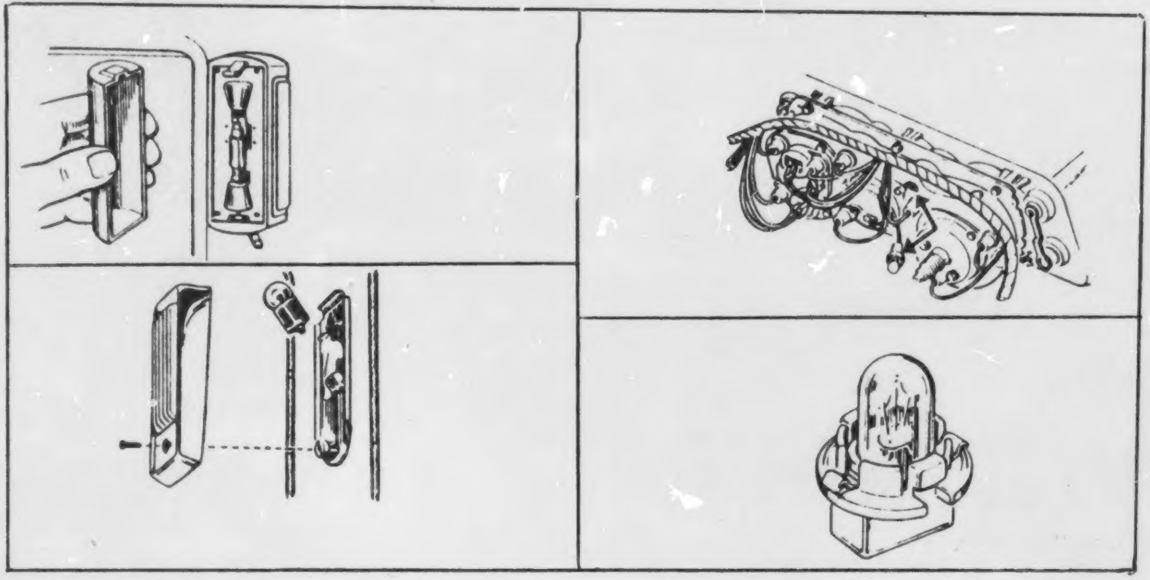


-Carefully pry out trim ring, then lens; install in reverse order. Another lens design on imported cars has no mechanical fastenings.
-Turn lens counterclockwise to disengage locking lugs.
NOTE: Always examine lens gaskets for damage that will allow moisture leakage. Always replace damaged gaskets.
Self-contained fog lights and spot lights, either sealed-beam or bulb types, have removable rims.
-Support glass portion as rim is removed; when re-installing, do not overtighten retaining screws.

Interior and Instrument

Some dome and courtesy lights are designed for cartridge-type bulbs, all others take bayonet-base bulbs.
-Lenses for these lights usually are held by Phillips-head screws; some may have a retaining rim; some types of dome and courtesy lights have a lens that is squeezed carefully to disengage retaining lugs.

Instrument lights usually are small bayonet-base bulbs. Normally, the entire socket is snapped out with a firm downward pressure; some remove with a counter-clockwise twist.



NOTE: The importance of quick replacement for burned-out instrument bulbs can't be stressed too much or too oftem. A car without one or more of these important bulbs could be driven with:

1. dangerously low oil pressure,
2. dangerously high engine temperature, or
3. a charging system that is malfunctioning. (On M.G. Sports Sedan, there is even a light that signals a clogged oil filter.)

Personally check instrument lights at every opportunity; also, ask motorists whenever possible if lights work at night, and if oil-pressure, charging system, or engine-temperature lights go on as key is turned to start engine.

Several car makers now use wedge-base bulbs for low-power lighting. (They look like miniature flash bulbs and are press-fit into their sockets.)

Plastic socket for wedge-base bulb is a "plug" inserted into instrument panel with twisting motion. (Bulbs and sockets of this type are used with printed-circuit instrument panels.)

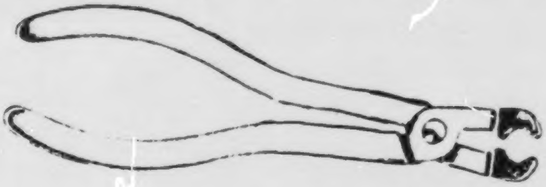
CAUTION: Make sure replacement bulbs are of correct size; a 6-volt bulb in a 12-volt system will burn out almost immediately; a 12-volt bulb in a 6-volt system will burn dimly, if at all. Care in selection of bulb replacements can avoid customer discontent,as well as unnecessary tracing work to find a problem that doesn't exist.

Lamp Replacement Tools

Tools are available on the market to assist the mechanic in the removal, cleaning, and installation of automobile lamps. Removal can become a problem when bulbs and sockets are subject to dirt, water, and salt; so tools such as bulb pliers or bulb base grippers can be very handy. If for instance corrosion becomes excessive and the bulb brakes while removing, a bulb base remover pliers works well. Once the bulb base has been removed cleaning may be necessary so a socket cleaning brush can be used. Finally a multi-purpose tool that aligns holes, pulls springs, and fits slotted and phillips screw heads is available.

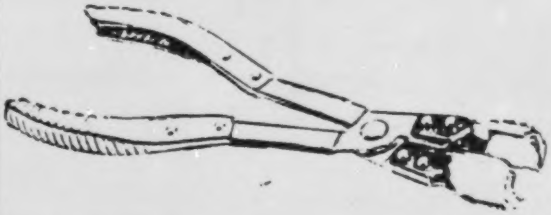
Bulb Pliers

Removes, installs bayonet and flange type bulbs. Jaws milled with sharp teeth for sure, non-slip grip on base of bulbs to prevent breaking glass. Also useful in removing bases of broken bulbs.



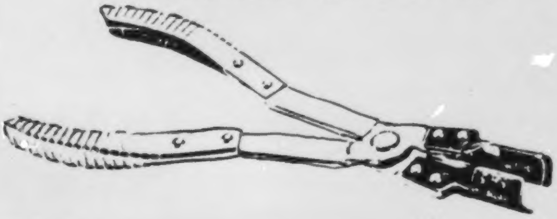
Bulb Base Gripper

Installs and removes light bulbs from tail lights, stop lights, turn signals, running lights on trucks, etc. Removes bulbs from corroded sockets. Plastic coated jaws permit soft, yet firm grip.



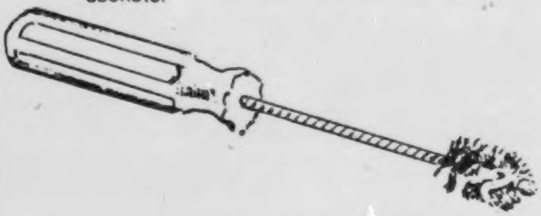
Bulb Base Remover Pliers

Removes corroded base when bulb is broken. Serrated lip on jaws gives firm hold for tight, positive grip without crushing bulb base.



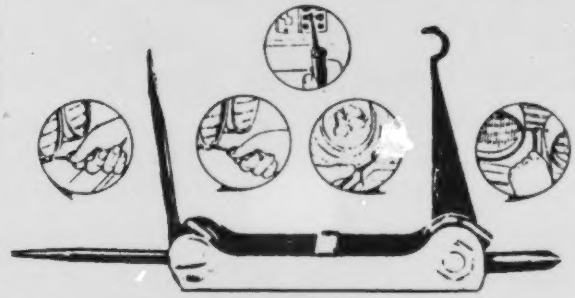
Socket Cleaning Brush

Removes corrosion and cleans light bulb sockets.



Headlight Fuse Tool Pak

Multi-purpose tool makes working on head lamps and changing fuses a "snap." Aligns screw holes on head lamp casings — pulls head lamp springs and reaches between double lamps with short screwdriver adapted to fit all Reed & Prince and Phillips-head screws.



Electrical Competencies - Body & Chassis

No. F-3 Lamp Replacement

Worksheet # 3

Name ____________________ Date __________ Grade __________

DIRECTIONS: Replace all the lamps listed below to pass this competency.

	Instructor's Check
Headlamp	____________
Type A,B, or C (bayonet type)	____________
Type E (or wedge base)	____________

NOTE: Check chart for proper replacement bulb.

Instructor's Initials __________

AUTO MECHANICS

Electrical Competencies - Body & Chassis

No. F-4 Headlight Aiming

OBJECTIVE:

Upon completion of this exercise the student will be able to adjust the headlight aim using one particular method or equipment.

EXPLANATION:

This will involve aiming headlights on a vehicle or vehicles using both methods if available.

MATERIALS NEEDED:

Mechanical aiming instructions.

TOOLS NEEDED:

Phillips screwdriver, aiming screen, masking tape, yard stick, mechanical aimer.

References	Do
#1. --	#1. Study reference assignment.
#2. --	#2. Refer to equipment instructions as to the operation of.
#3. --	#3. Complete worksheet.
#4. --	#4. Check with instructor.
#5. p. 528-530	
#6. --	
#7. --	
#8. p. 178-187	

Electrical Competencies - Body And Chassis

No. F-4 Headlight Aiming

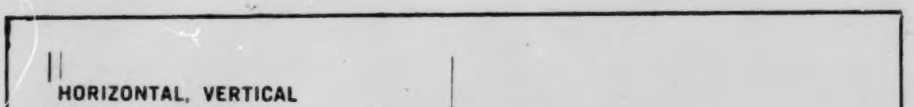
Information Sheet #1

General Information

Headlights are generally designed and manufactered correctly, but will only function correctly when they are properly aimed. Headlight aiming is the largest single item found to be faulty in safety check lane inspections. There are four different methods currently used to aim and adjust headlights: visual, optical, photoelectric, and mechanical. We will be discussing the visual and mechanical methods in this section.

The headlights must be checked for proper aim when ever a sealed beam unit is replaced and after any adjustment or repair of the front end sheet metal assembly. The bulb is fastened in a metal adjuster ring. The adjuster ring has one screw that controls horizontal movement and another that controls verticle movement. These are used to place the light beam hot spot in the correct position so that it will provide the driver with maximun road lighting.

Some manufacterers, in their aiming instructions, call for a full fuel tank and an empty car. Others call for a partly full tank and two people in the front seat. The trunk should be empty except for the spare tire and jacking equipment. Tires must be installed to specified pressure. Also any snow or mud accumulation found on the front or rear of the car should be removed. And finally before aiming the cars suspension system should be equalized by rocking or bouncing.



Visual Aiming

Of the several methods of checking headlight aim, probably the simplest and least costly as far as equipment goes is the visual aim.

1. Locate the car in a darkened, level area square with a screen or wall having a nonreflecting white surface and with the front of the headlamps directly over a reference line of 25 feet from the screen.

2. Locate the middle of the aiming screen in line with the center of the car. This can be done by marking the center of the front and rear windows with a narrow strip of marking tape. Use these sights to locate and mark the center of the aiming screen directly in line with the car axis.

3. Measure the horizontal distance between the lamp centers.

4. Position a dark colored tape vertically to the right of marked centerline at half this distance. Place another tape vertically to the left of the centerline a similar distance.

5. Measure distance from the center of each lamp to th surface on which the car rests. Mark the same height measurement on the screen using a piece of tape. Turn the headlamps on low beam and cover one lamp.

6. Turn vertical aiming screw, located at top position of lamp housing, counterclockwise until beam has been considerly lowered. Then turn screw clockwise until the top edge of the high intensily portion of the lower beam is even with the horizontal line.

7. Turn the horizontal aiming screw, located at the side of the lamp housing, counterclockwise then clockwise, until left edge of high intensity area at lower beam is 2 inches to the right of the lamp centerline.

8. Cover lamp that has been aimed and follow the above procedure for the opposite lamp.

9. Turn lead lamps on high beam and cover all lights not being adjusted.

10. Turn verticle aiming screw, located at top position of lamp housing counterclockwise until beam has been considerably lowered. Then turn screw clockwise until the top edge of the high intensity portion of the beam is 2 inches below the horizontal time.

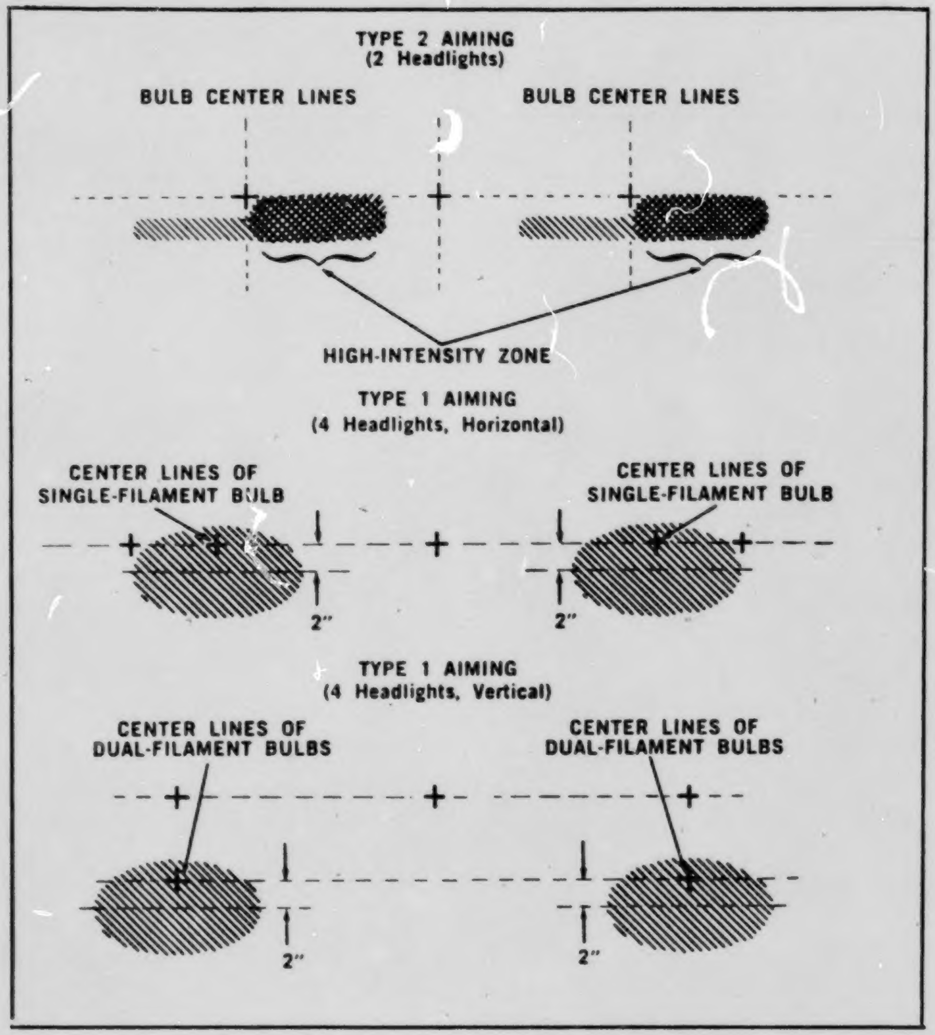
11. Turn the horizontal aiming screw, located at the side of the lamp housing counterclockwise then clockwise until left edge of high intensity area is on center.

12. Cover lamp that has been aimed and follow the above procedure for the opposite lamp.

NOTE: Tap lamp lightly with hand after making an adjustment of the aiming screws. This assures proper tension against the screws to avoid any change in aiming due to road bumps or vibrations.

Correct Aiming

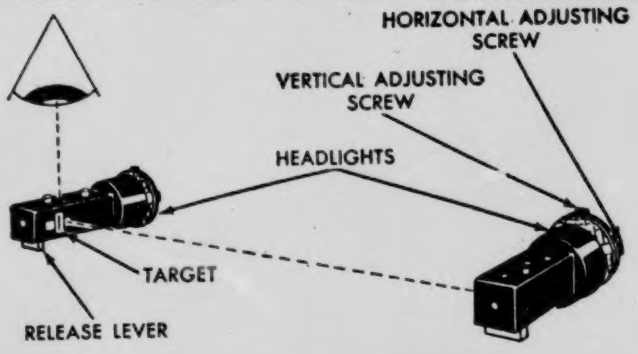
The hot spots for two element low beam position are aimed to a spot indexing within six inches to the right of the vertical centerline of the lamp and two inches below a horizontal centerline through the lamp when projected on the screen 25 feet ahead of the car. Aiming this element automatically aims the upper beam element properly.


TYPE 2 AIMING
(2 Headlights)
BULB CENTER LINES
BULB CENTER LINES
HIGH-INTENSITY ZONE
TYPE 1 AIMING
(4 Headlights, Horizontal)
CENTER LINES OF SINGLE-FILAMENT BULB
CENTER LINES OF SINGLE-FILAMENT BULB
2"
2"
TYPE 1 AIMING
(4 Headlights, Vertical)
CENTER LINES OF DUAL-FILAMENT BULBS
CENTER LINES OF DUAL-FILAMENT BULBS
2"
2"

Mechanical Aimers

Light-beam aiming requires a relatively dark area. Mechanical aimers have been devised for use in full daylight. They are built with mathematical corrections to aim the light bulbs as accureately as with the light beam method. Mechanical aimers are seated against three reference locating lugs provided on the bulb. Specific operating details differ between aimers. In general, they use spirit levels, strings, and reflecting mirrors with split images to align hieadlight pairs. Some aimers used in daylight use the headlight beam with optics so the pattern in the aimer appears the same as it would be on the viewing screen.

No matter what method is used, Headlights should be accurately aimed for proper night visibility. At today's driving speeds, any light less than the maximum possible does not give the driver sufficient reaction time in case there is an unexpected change in the road ahead.



Mounting and adjusting aimers

Electrical Competencies- Body & Chassis

No. F-4 Headlight Aiming

Worksheet #1

Name ______________________ Date ________________ Grade __________

Directions: Fill in the needed information on the lines provided.

What are the legal headlight aiming requirements?

____

____

____

____

List the steps and procedures for headlight aiming, using your equipment. (From the operating instructions for your equipment).

____

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Instructor's Initials __________

AUTO MECHANICS

Electrical Competencies– Body & Chassis

No. F- 5 Connect Trailor Light Coupling Connector

OBJECTIVE:

Upon completion of the following material, you will be able to correctly connect a trailor light coupling connector to the automobile lighting circuit following accepted wiring standards.

EXPLANATION:

This will involve locating wiring diagrams, identifying wire color codes, and connecting a coupling.

MATERIALS NEEDED:

Coupling connector, manufacturers electrical manual wire connectors, and turn and brake signal adaptor (optional)

TOOLS NEEDED:

Test light, crimping pliers, wire cutters and strippers

References	Do
#1. --	#1. Study information sheet #1.
#2. --	#2. Check with instructor for assigned vehicle.
#3. --	#3. Perform trailer connector wire up.
#4. --	#4. Complete worksheet #1.
#5. --	#5. Turn worksheet in for instructor check.
#6. --	
#7. --	
#8. --	

Electrical Competencies- Body & Chassis

No. F-5 Connect Trailer Light Coupling Connector

Information Sheet #1

State Laws Regarding Trailer Lighting

According to state laws 347.13, 347.14, and 347.15, no person shall operate a motor vehicle or trailer unless equipped with tail, stop, and signal lights.

Law 347.16 states that no person shall operate on a highway during the hours of darkness any vehicle except automobiles, having a width at any part in excess of 80 inches unless such vehicle is equipped with:

a. Two clearance lamps mounted on the front of the vehicle so as to be visible from the front and,
b. Two clearance lamps mounted on the rear of the vechicle so as to be visible from the rear, and,
c. Two reflectors mounted on the rear of the vehicle in such a manner so as to indicate as nearly as possible the extreme width of the vehicle.

Law 347.17 states whenever a vehicle is equipped with clearance lamps, side marker lamps, and reflectors;

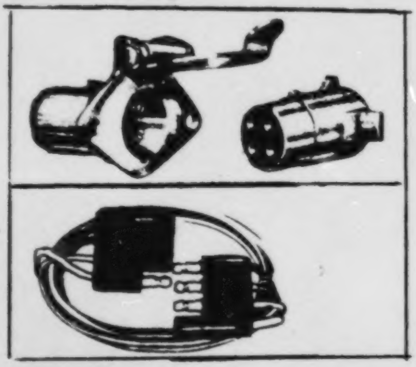
a. Those clearance and marker lamps and reflectors mounted on the front or on the side near the front of the vehicle shall display or reflect an amber color;
b. Those clearance lamps and marker lamps and reflectors mounted on the rear or on the sides near the rear of the vehicle, or on both, shall display or reflect a red color.

Trailer Coupling Connectors

The electrical lighting system of a trailer is a fairly simple operation as long as a few precautionary measures are taken. A poor trailer connector can cause a voltage drop in the trailer lighting circuit even though the vehicle has an ample electrical power supply. Proper connection of the connector cord wires at the male and female connector plugs is of primary importance to assure a minumum voltage drop. The connector should also be weather proof, and connect or disconnect easily.

There are four basic coupling connectors covered in this section, the four, six, and seven way.

4-Way



There are two types of 4-way connectors shown, the two piece pole connector is used for permanent mounting. The flat or sleeve type can be stored in the trunk when not being used. The top connector has a few advantages of being more dirt and water resistant and more durable than the flat.

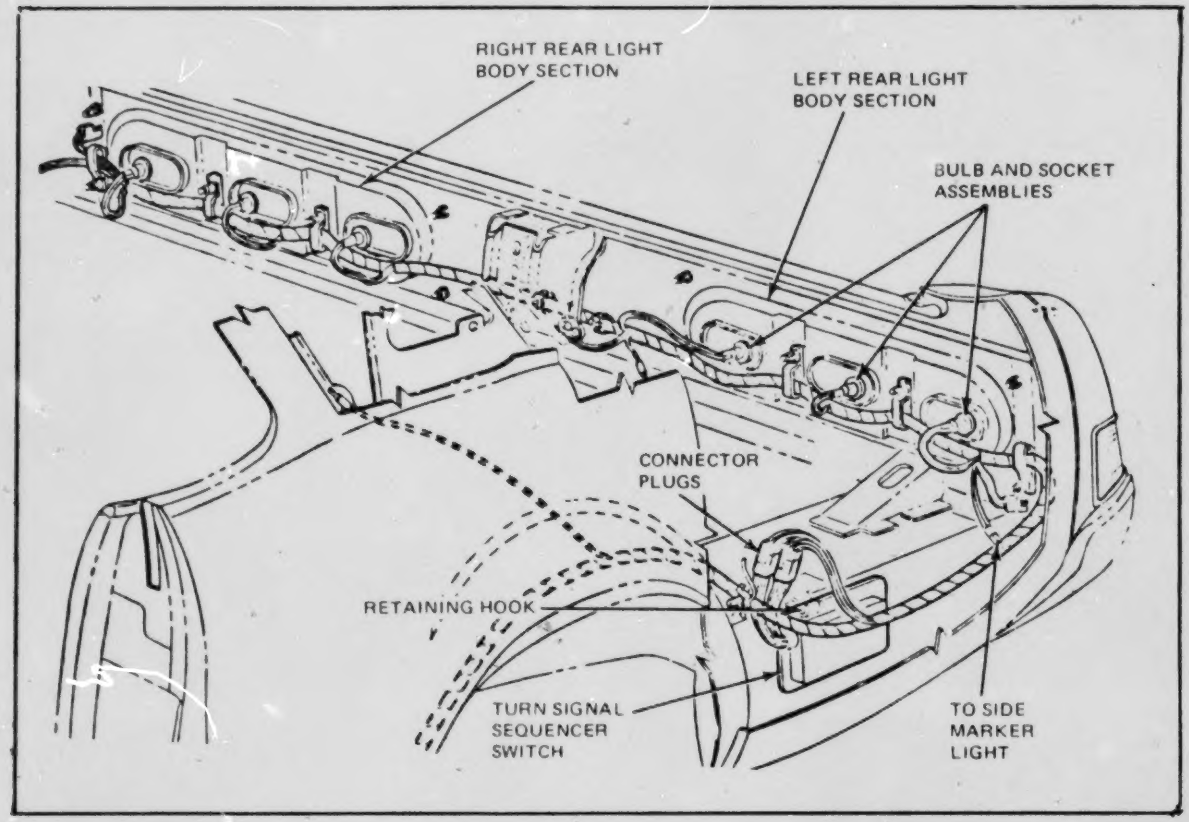
Standardized Color Codes

Color coding makes the job of wiring a trailer much easier. According to the Federal Motor Vehicle Safety Standards all trailer light wiring shall be color coded the same. Listed below are the wire colors adn where they are used.

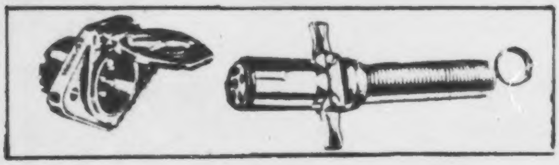
a. white- Ground returning to towing vehicle
b. yellow- Left hand turn signal and hazard warning
c. green- Right hand turn signal and hazard warning
d. brown- tail, clearance, and side marker lights
e. red- stop lamps or electric brake
f. blue- Auxilary
g. black- Identification, clearance, sidemarker lamps, or backup lamps.

Rear Wiring Harness

The illustration below shows accessably exposed portions of the rear wiring harness on a typical automobile. In most cases it 's not necessary to remove the outer door and light body assembly. Splicing directly into the wiring harness inside the trunk is the easiest and fastest way. Some may want to install a connector thats exposed to the outside at all times. This can be done by drilling a hole and bolting it in.

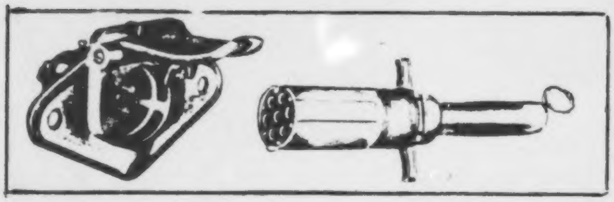

RIGHT REAR LIGHT BODY SECTION
LEFT REAR LIGHT BODY SECTION
BULB AND SOCKET ASSEMBLIES
CONNECTOR PLUGS
RETAINING HOOK
TURN SIGNAL SEQUENCER SWITCH
TO SIDE MARKER LIGHT

6-Way

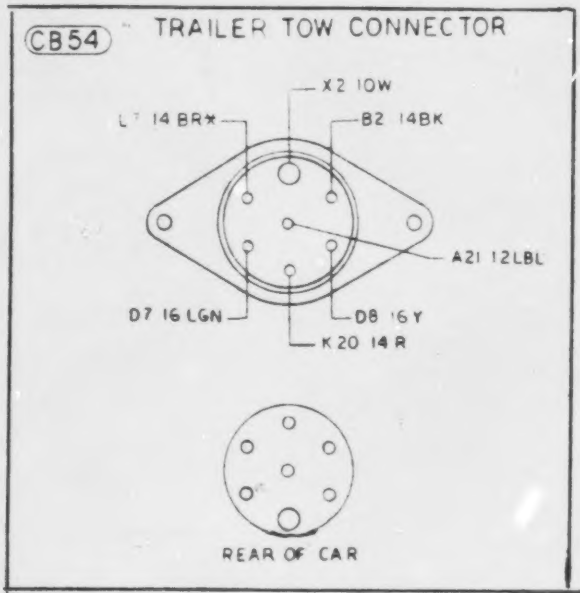


The 6-way connector works in the same manner as the 4-way except it has two extra wires. Usually a red wire is used for stoplights, where in a 4-way the green and yellow supplied turn and stop light. A blue wire can be added for an auxilliary circuit, or a black wire for clearance lights . The red wire could also supply electric brakes.

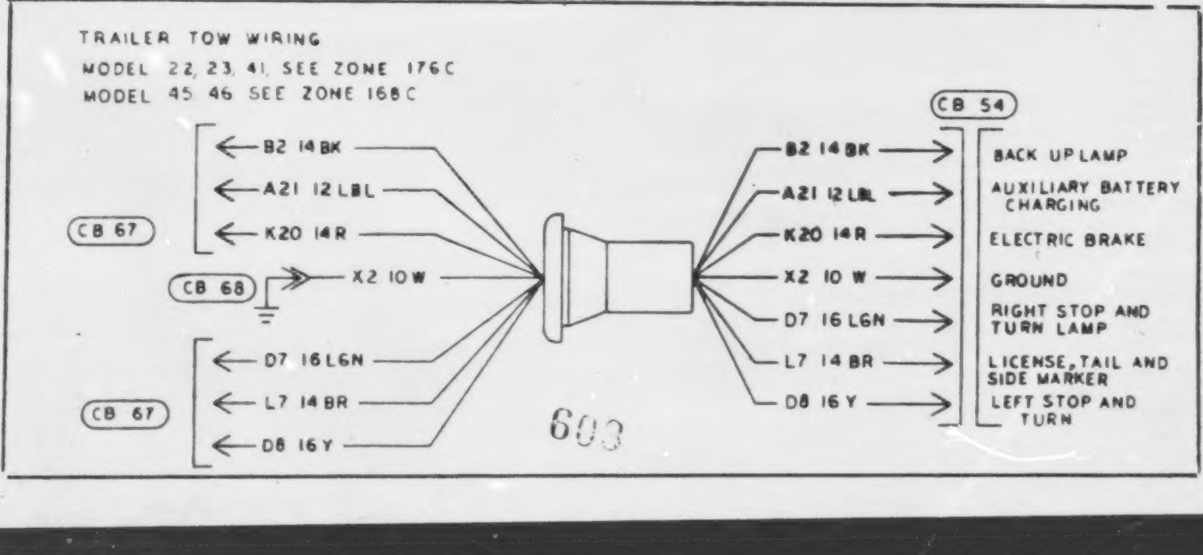
7-Way



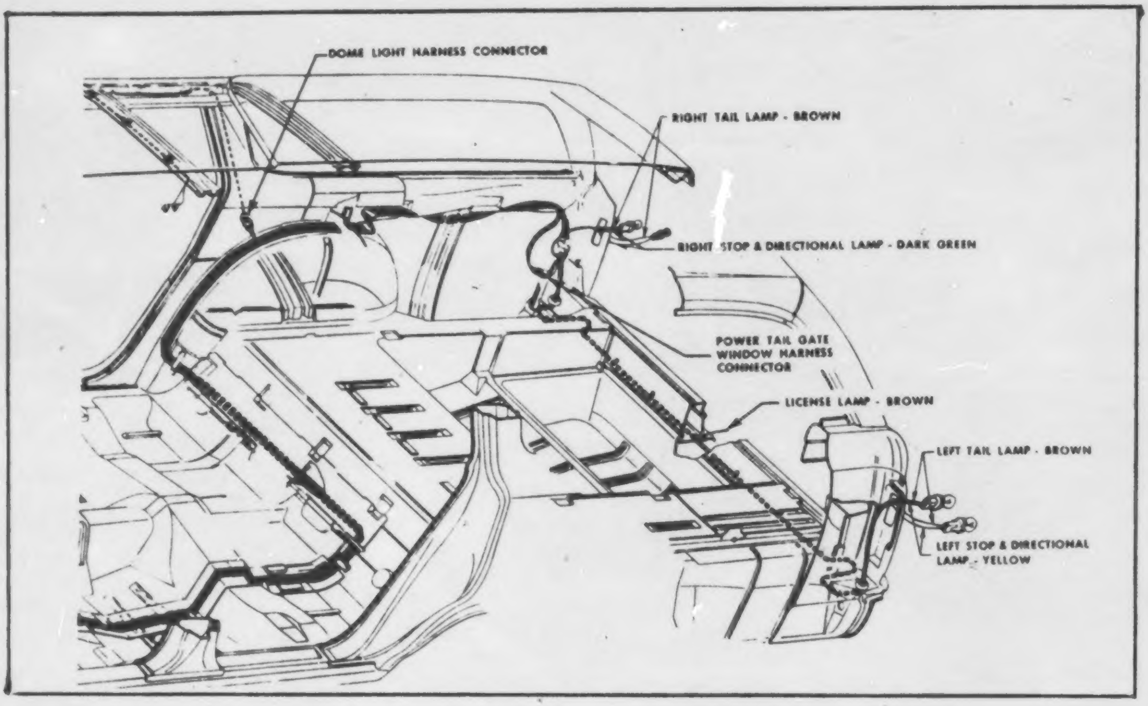
According to state law clearance lights must be present on trailers 80 inches or more in width. So a 7-way connector is used with a black wire added for identification, clearance, and side marker lights.


CB54
TRAILER TOW CONNECTOR
X2 10W
L7 14 BR*
B2 14BK
A21 12LBL
D7 16 LGN
D8 16 Y
K20 14 R
REAR OF CAR

A typical trailer connector as seen in a wiring diagram shows the placement of the wires and a color code for easy identification.


TRAILER TOW WIRING
MODEL 22, 23, 41, SEE ZONE 176C
MODEL 45 46 SEE ZONE 168C
CB 67
B2 14 BK
A21 12 LBL
K20 14 R
CB 68
X2 10 W
CB 67
D7 16 LGN
L7 14 BR
D8 16 Y
CB 54
B2 14 BK
A21 12 LBL
K20 14 R
X2 10 W
D7 16 LGN
L7 14 BR
D8 16 Y
BACK UP LAMP
AUXILIARY BATTERY CHARGING
ELECTRIC BRAKE
GROUND
RIGHT STOP AND TURN LAMP
LICENSE, TAIL AND SIDE MARKER
LEFT STOP AND TURN

Another illustration shows the rear wiring harness for a station wagon. With this type of vehicle it may be more difficult to acquire access to the wiring. Interior panels may have to come off or outer light body, and door assemblies removed.


DOME LIGHT HARNESS CONNECTOR
RIGHT TAIL LAMP - BROWN
RIGHT STOP & DIRECTIONAL LAMP - DARK GREEN
POWER TAIL GATE WINDOW HARNESS CONNECTOR
LICENSE LAMP - BROWN
LEFT TAIL LAMP - BROWN
LEFT STOP & DIRECTIONAL LAMP - YELLOW

Wire Identification

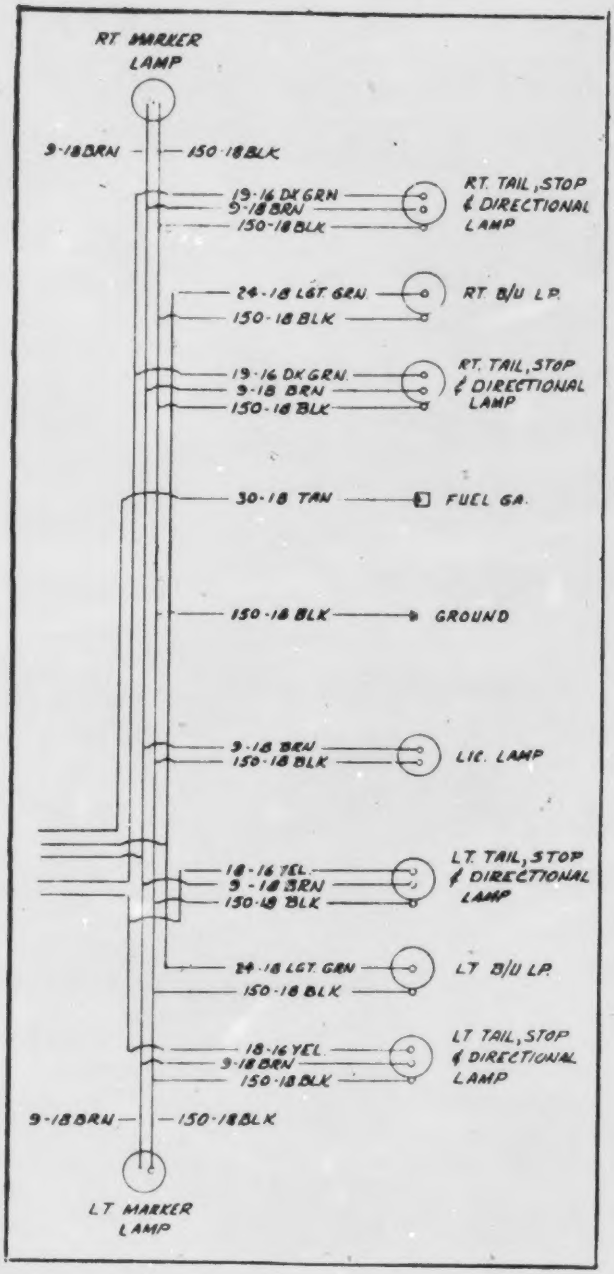
Wire identification when hooking up connectors can be done using three different methods.

Method 1. A visual identification of wire colors as they enter the taillight/ stoplight bulb sockets will tell you the function of the wires. Left and right taillight wires will be of the same color, while left and right turn signal/ stoplight wires will be of different colors corresponding to their direction. Follow the connector color code when making the hook up.

Method 2. Obtain a wiring diagram, as shown on the following page, of your particular vehicle. All bulbs and wires are labeled which makes wire identification faster and fool proof.

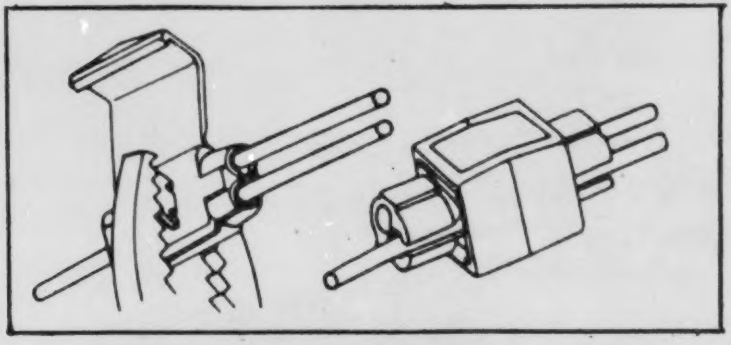
Method 3. Use a test light to identify the correct wire in the harness during actual circuit operation. For example, pull headlight switch to park/ taillight position, connect test light lead to ground, and probe each wire until you find a hot lead. Test lamp will light. To verify circuit, turn off taillights and recheck wire. Test lamp should not light. Repeat this procedure with left and right turn signals. Follow connection color code when making hookup.

In the event that additional wiring is required for auxilliary circuits or electric brakes, make sure the added circuit is of adequate size and contains a circuit protection device.

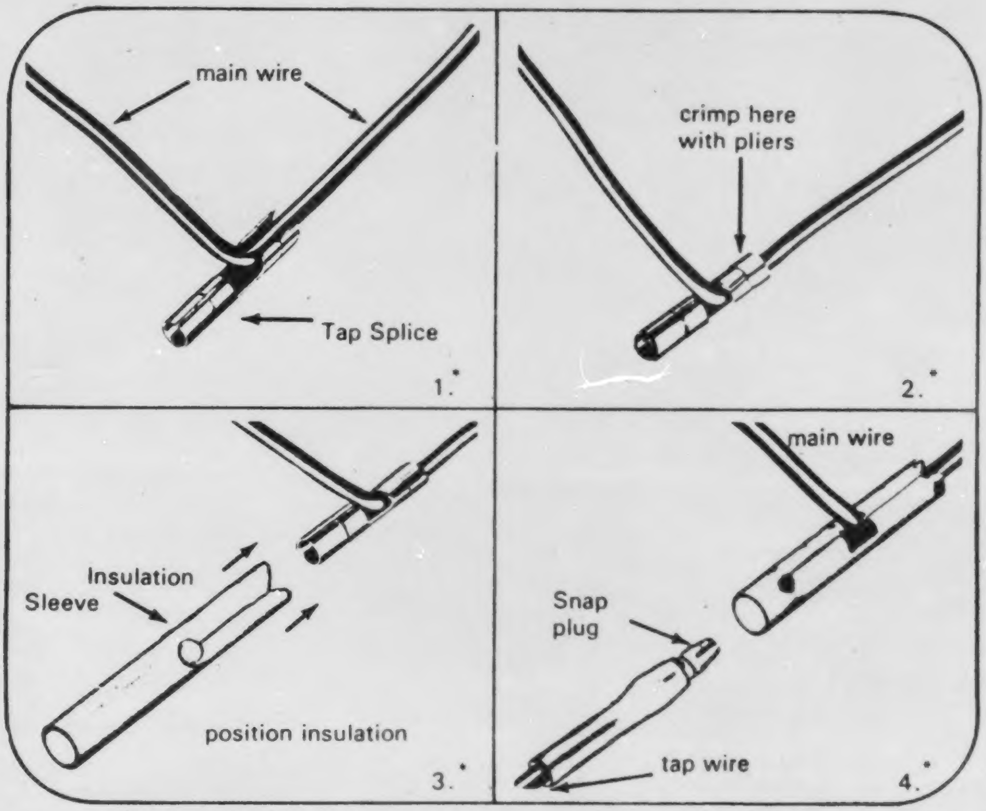

RT. MARKER LAMP
9-18 BRN
150-18 BLK
19-16 DK GRN
9-18 BRN
150-18 BLK
RT. TAIL, STOP & DIRECTIONAL LAMP
24-18 LGT. GRN.
150-18 BLK
RT. B/U LP.
19-16 DK GRN.
9-18 BRN
150-18 BLK
RT. TAIL, STOP & DIRECTIONAL LAMP
30-18 TAN
FUEL GA.
150-18 BLK
GROUND
9-18 BRN
150-18 BLK
LIC. LAMP
18-16 YEL.
9-18 BRN
150-18 BLK
LT. TAIL, STOP & DIRECTIONAL LAMP
24-18 LGT. GRN
150-18 BLK
LT B/U LP.
18-16 YEL.
9-18 BRN
150-18 BLK
LT TAIL, STOP & DIRECTIONAL LAMP
9-18 BRN
150-18 BLK
LT. MARKER LAMP

Wire Connectors

Two types of wire connectors work well when splicing into a wiring harness for trailer lights. "The lock" type can be used to connect the main wire to the tap wire by sliding the main wire up through the bottom slot and pushing the connector or tap wire into the upper hole Make sure the tap wire is held in securely and using a pair of pliers snap the metal clip connecitng the two wires. Finally shut the door around the connector.



The tap splice connector is another good way to join two wires together. Picture #1 shows the main wire being placed into the tap splice, where a needle like point is pushed into the wire. Picture #2 shows the tap splice being crimped to secure the main wire. Picture #3 has an insulating sleeve being positioned over the splice to avoid grounding. Last, the snap plug is pushed into the tap splice and the complete assembly is joined.


main wire
Tap Splice
1.
crimp here with pliers
2.
Insulation Sleeve
position insulation
3.
main wire
Snap plug
tap wire
4.

Late Model Domestic and Foreign Car Trailer Connections

Some of the late model foreign and domestic automobiles are being produced with an individual amber turn signal. In this situation a special electronic converter must be used to incorporate the stop and turn signal lights. Of the lighs on the trailer must also have an amber turn signal installed. Below is a set of instructions for installing an electronic converter.

WIRING INSTRUCTIONS

WESBAR ELECTRONIC CONVERTER

This device, when properly connected to your auto and trailer circuits will give trouble-free service in the functioning of trailer stop and turn signals.

CAUTION: GROUND WIRES (WHITE) **must** be connected to both car and trailer for proper functioning of the electronic converter. Taillight wire (brown) is provided for easy connection for complete lighting hook-up.

Since this is an electronic device, it is subject to electrical damage if it is short-circuited or improperly connected.

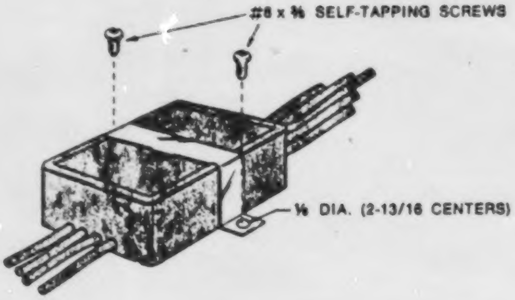
The schematic diagram on the decal clearly shows how the unit must be connected to car and trailer. The color coding of the wire is as follows:

Connections to Car

Ground: White
Right Turn: Green
Left Turn: Yellow
Taillight: Brown
Stop: Red

Connections to Trailer

Taillight: Brown
Right Turn and Stop: Green
Ground: White
Left Turn and Stop: Yellow



MOUNTING INSTRUCTIONS

To mount Electronic Converter in a fixed position, drill (2) ⅛" dia. holes (see diagram at left), and secure with the (2) No. 8 self-tapping sheet metal screws in the trunk of your car.

Substituting Turn Signal and Hazard Flasher Units

In certain cases it may be necessary to subsittute your hazard flasher unit or purchase a heavy duty flasher unit when connecting a trailer. This will provide a constant flash rate when adding bulbs to a circuit. The only disadvantage to the placement is that it gives the driver no indication that the bulb has burned out. For more information, see Competency F-14.

Electrical Competencies- Body & Chassis

No. F-5 Connect Trailer Light Coupling Connector

Worksheet #1

Name ______________________ Date ______________ Grade __________

Instructions: After wiring in a trailer light connector coupling, complete the following:

1. List the seven wire colors and respective functions in a trailer circuit.

____

____

____

____

____

____

____

____

____

____

2. Identify the type of connector coupling which was used.

____

____

3. Describe the method used to locate the correct wires in the vehicle rear lighting harness.

____

____

____

____

____

____

4. Describe how the trailer turn signals would operate if the ground wire (white) were not connected to the vehicle.

____

____

____

____

____

Worksheet #1
Page 2

5. If the trailer wire connections did not match your connector, which wire hook up would you change? (trailer or vehicle) and why?

Instructor's Initials ___________

AUTO MECHANICS

Electrical Competencies_ Body & Chassis

No. F-6 Wire A Trailer

OBJECTIVE:

Upon completion of this material, you will be able to install and connect all lighting and wiring materials necessary to provide legal lighting equipment on a typical automobile towed trailer.

EXPLANATION:

MATERIALS NEEDED:

trailer
light units
wire
connectors
solder
heat shring tubing

TOOLS NEEDED:

hand tools
soldering iron

References	Do
#1. --	#1. Read information sheet #1.
#2. --	#2. Check with instructor for assigned trailer.
#3. --	#3. Perform wire up on trailer.
#4. --	#4. Have instructor check work and light operation.
#5. --	
#6. --	
#7. --	
#8. --	

Electrical Competencies- Body & Chassis

No. F-6 Wire A Trailer

Information Sheet #1

Proper wiring of typical automobile or light truck towed trailers is not difficult. If not done properly, however, it may lead to dangerous lighting failure, often when the trailer owner is miles away from home. Trailers which are not wired following the standard color code often create problems by not being adaptable to more than one tow vehicle. If the owner, using a differenct tow vehicle, is not aware of the problem, he may create a hazard with the improperly operating lights.

The information provided in this competency will aid the mechanism in installing new or repairing older wiring on typical trailers.

State Laws Regarding Trailer Lighting

According to state laws 347.13, 347.14, and 347.15, no person shall operate a motor vehicle or trailer unless equipped with tail, stop, and signal lights.

Law 347.16 states that no person shall operate on a highway during the hours of darkness any vehicle except automobiles, having a width at any part in excess of 80 inches unless such vehicle is equipped with:

a. Two clearance lamps mounted on the front of the vehicle so as to be visible from the front, and,
b. Two clearance lamps mounted on the rear of the vehicle so as to be visible from the rear, and,
c. Two reflectors mounted on the rear of the vehicle in such a manner so as to indicate as nearly as possible the extreme width of the vehicle.

Law 347.17 states whenever a vehicle is equipped with clearance lamps, side marker lamps, and reflectors;

a. Those clearance and marker lamps and reflectors mounted on the front or on the side near the front of the vehicle shall display or reflect an amber color;
b. Those clearance lamps and marker lamps and reflectors mounted on the rear or on the sides near the rear of the vehicle, or on both, shall display or reflect a red color.

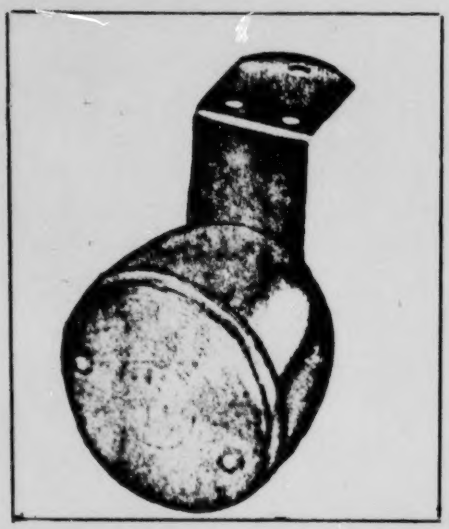
Standardized Color Codes

Color coding makes a job of wiring a trailer much easier. According to the Federal Motor Vehicle Safety Standards, all trailer light wiring shall be color coded the same. Listed below are the wire colors and where they are used.

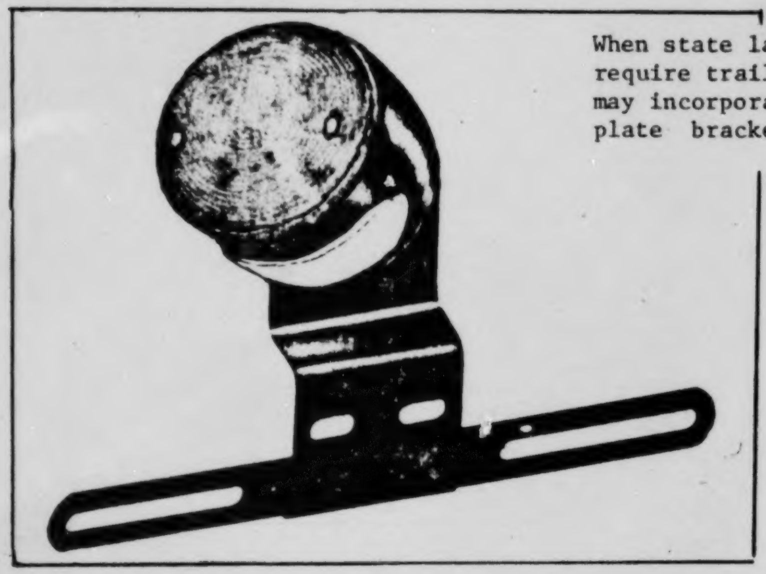
a. white- ground return to towing vehicle
b. yellow- left hand turn signal and hazard warning
c. green- right hand turn signal and hazard warning
d. brown- tail, clearance, and side marker lights
e. red- stop lamps or electric brake
f. blue- auxilliary
g. black- identification, clearance, side marker lamps, or backup lamps

Trailer Lighting Equipment

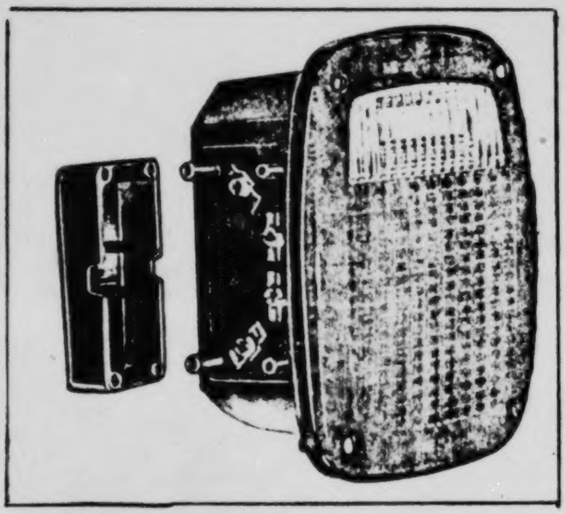
Light units and wiring supplies are available from several sources. Below are some examples of light units suitable for use on trailers. Note that the light unit selection often depends on expected adverse operating conditions. Where the unit is subjected to constant water and salt contamination for example, a well sealed unit will out last most normal units and justify the extra expense.



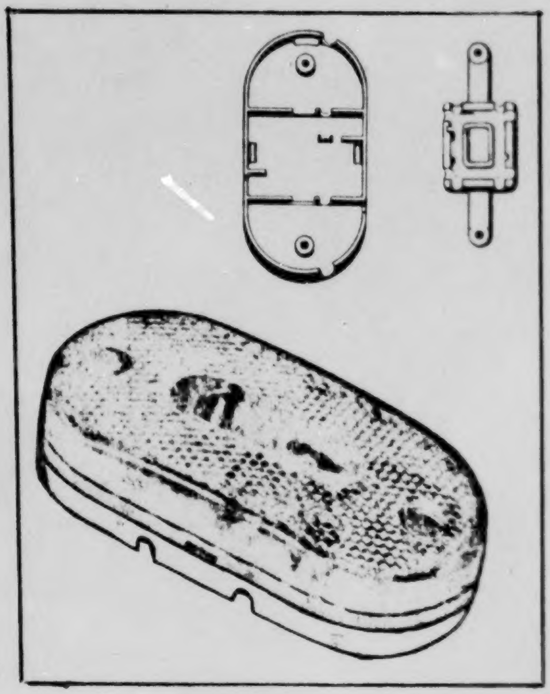
Combination tail stop and turn lights are available. The unit at left is typical with the "L" shaped bracket being optional.



When state laws or heavier weight loads require trailer licensing, the light unit may incorporate a license light lense and plate bracket.



The light unit at left is is a sealed unit which includes a backup light. Note the wire connection compartment which can utilize "U" terminals. Typical unsealed lamp units can be aided with "RTV" silicone sealers.



Clearance light units are available for trailers when required due to width. The light unit at left is designed for continuous exterior wiring applications. No cutting or stripping of the wire is required. The unit is simply placed over the wire run and an insulation piercing blade makes contact. It is available in red and amber.

Trailer Wire Size Requirements

When wiring a complete trailer, consideration must be given to expected electrical load and corresponding wire size.

Correct wire gauge size can be calculated using the current ratings of the lamps you are using and a wire gauge/load charts. Lamp ratings can be found in Competency F-3, information Sheet #1, page 4A. A chart providing wire gauge/load information is presented in Competency A-5, information sheet #3, page 7.

For example, a brake light circuit using two 1157 lamps will require 4.20 amps current flow. If the trailer circuit were no more than 20 ft. long, a 20 gauge wire size would be sufficient. If we are to consider a need for more mechanical strength, we should use an 18 gauge wire.

When concerned with a trailer ground wire size, we must consider that all current required by all the trailer lighting and any auxilliary equipment must pass through this one wire. In most cases a 12 or even a 10 gauge ground wire size is required.

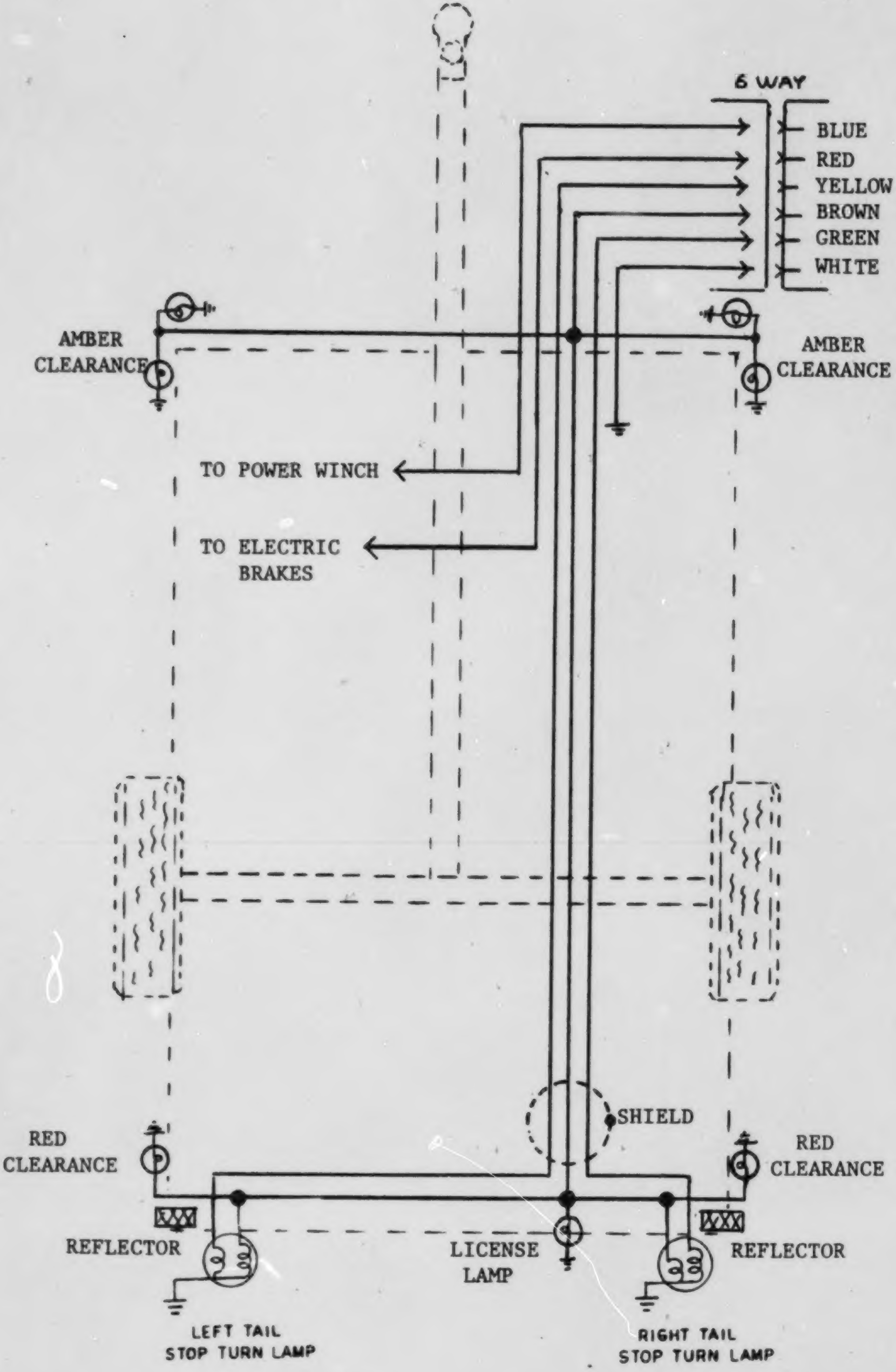
Always remember that a wire size that is too small for its job will result in excessive voltage drop and weak or dim lighting. Also, an excessive number of lighting units may overload the tow vehicles circuit protection devices.

Trailer Wiring Connectors

When selecting wiring connecting devices for use on a trailer, one should consider mechanical strength and corrosion resistance. Since much of the trailer's wiring is typically exposed to road debris and water splash, proper selection of materials is vitally important to a long lasting wiring job. A coverage of wire connecting methods is included in competency A-8. For trailer wiring, soldering and the use of heat shrink tubing is strongly recommended.

Trailer Wire Diagram

The wire diagram on the following page illustrates a typical wire hook up. The wiring system makes use of a 6-way connector, and includes circuits for clearance lighting, electric brakes, and a power winch. If upper clearance lights, or trailer backup lights were to be added, a 7-way connector with a black code circuit would be necessary. Note that a shield symbol is used. When wiring a new trailer, it is strongly recommended that long wire runs be enclosed in conduit or routed through the trailer frame for durability.


6 WAY
BLUE
RED
YELLOW
BROWN
GREEN
WHITE
AMBER CLEARANCE
AMBER CLEARANCE
TO POWER WINCH
TO ELECTRIC BRAKES
SHIELD
RED CLEARANCE
RED CLEARANCE
REFLECTOR
REFLECTOR
LICENSE LAMP
LEFT TAIL STOP TURN LAMP
RIGHT TAIL STOP TURN LAMP

AUTO MECHANICS

Electrical Competencies - Body and Chassis

No. F-7 Interpret Wiring Diagrams

OBJECTIVE:

Upon completion of the following material, you will be able to interpret an automobile wiring diagram to the degree necessary to trace an electrical circuit from its component to its power source.

EXPLANATION:

This unit will cover symbols, designations, and coding methods used on wiring diagrams along with a guided exercise in tracing a complete circuit on a typical wiring diagram.

MATERIALS NEEDED:

TOOLS NEEDED:

Pencil

References	Do
1.	1. Study information sheets
2. Ch. 19, p. 400	2. Check with instructor for assigned component
3. Pp. 426-436	3. Trace the circuit for the component
4. Pp. 429-33, pp. 686-7	4. Enter all information requested on Worksheet #1
5. Ch. 32, pp. 522-25	5. Check with instructor
6. Ch. 34 pp. 322-34, Ch. 60, p. 599-604	
7. Ch. 23, pp. 282-97	
8. Ch. 6, pp. 114-141	

Electrical Competencies - Body & Chassis

No. F- 7 Interpret Wiring Diagrams

Information Sheet # 1

Introduction to Wiring Diagrams

Sources

The wiring diagrams for Chrysler, General Motors, and American Motors Corporation are published in their respective yearly service manuals. General Motors, in addition to the service manual, also publishes a separate wiring diagram book for each of the car lines. Ford Motor Company annually publishes their wiring diagrams for all car lines in a book entitled "Car Wiring and Vacuum Diagrams".

In addition to the automobile manufacturers wiring diagrams, service publications from Mitchell Manuals and Motors also include wiring diagrams. Motor's "Vacuum and Wiring Diagrams" edition is unique in that it covers more than one year.

In the past, automotive wiring diagrams were not standardized and it was difficult to adjust to each diagram scheme. There were too many wires shown on one page and it was often necessary to flip back and forth between the several schematics that made up and illustrated the electrical system. They also lacked data for locating components and connectors on the car; although this is still a problem with some of the sources listed above- i. e. General Motors, A. M. C.

The modern trend is to feature the entire electrical system on one schematic. It may be a multiple-page diagram, but the schematic continues from page to page with no need for flipping back and forth. The better schemes from Ford and Chrysler are coded to show where every component, connector, and switch are located on the vehicle. This in itself is one important reason to understand how to read a wiring diagram. Otherwise, locating components, connectors, and switches in circuits not familiar to you could become an extremely time consuming job.

The following material will attempt to cover all current type of wiring diagrams, and will concentrate on how to read the newer types. Much of the information can be related to automotive wiring diagrams which still use the traditional lay out schemes of previous years.

Electrical Competencies- Body & Chassis

No. F-7 Interpret Wiring Diagrams

Information Sheet #2

Wiring Diagram Elements

The following information will be concerned with:
1. wire identificaiton on diagrams
2. wire splice symbols
3. wire connector symbols
4. common electrical symbols
5. special provisions

Wire Identification

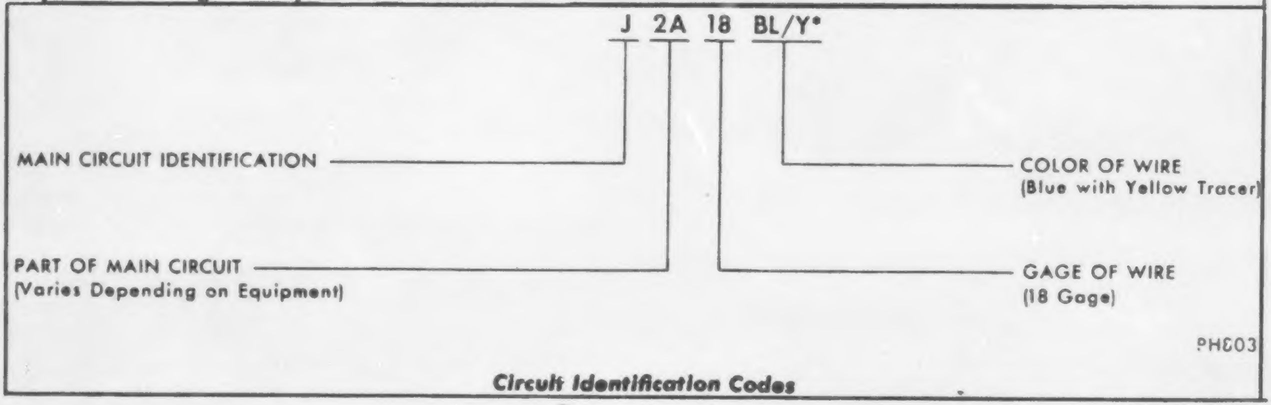
When viewing a wiring diagram for the first time, your impression is the confusion created by a mass of lines depicting wires in the circuit. Although the system looks complicated,each of these wires can be identified as to the circuit it serves, its size (gauge), and its color. Some wiring diagrams will even tell you where to locate the wire and its harness in the vehicle. When using a wiring diagram for the first time, it is best to study the instructions usually found at the beginning of the wiring section. This will give you accurate information pertaining to understanding the wiring lay out and identify its parts.

Circuit codes:

Chrysler and Ford wiring diagrams use circuit codes as part of the information included with each wire designation. General Motors uses circuit codes, but only on the connector symbol terminals. All of these codes can be referenced to a chart located on or before the diagram. American Motors Corporation does not have specific circuit codes but uses a system of letter codes to designate connector terminals. Motor's diagrams are copies of the manufacturers which include circuit codes, however Motors does not provide an index chart. Mitchell Manuals do not use any codes. Chrysler and General Motors circuits codes are shown below.

MAIN CIRCUIT IDENTIFICATION CODES

A1	Battery Circuit to Ammeter.
A2	Battery Circuit to Ammeter.
B	Back Up Lamp Circuit.
C	Air Conditioning and Heater Circuits
D	Emergency, Stop Lamp and Turn Signal Circuits.
E	Instrument Panel Cluster, Switches and Illumination Circuits.
F	Radio Speakers and Power Seat Circuits.
G	Gauges and Warning Lamp Circuits.
H	Horn Circuit.
J	Ignition System Run Circuit.

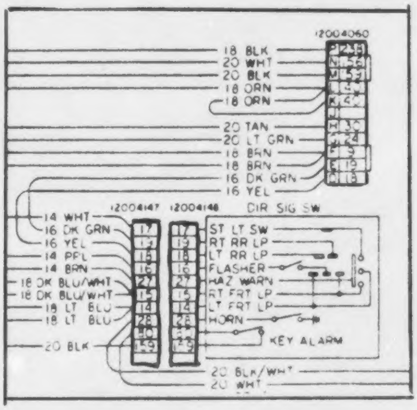

J 2A 18 BL/Y*
MAIN CIRCUIT IDENTIFICATION
PART OF MAIN CIRCUIT
(Varies Depending on Equipment)
COLOR OF WIRE
(Blue with Yellow Tracer)
GAGE OF WIRE
(18 Gage)
PH603

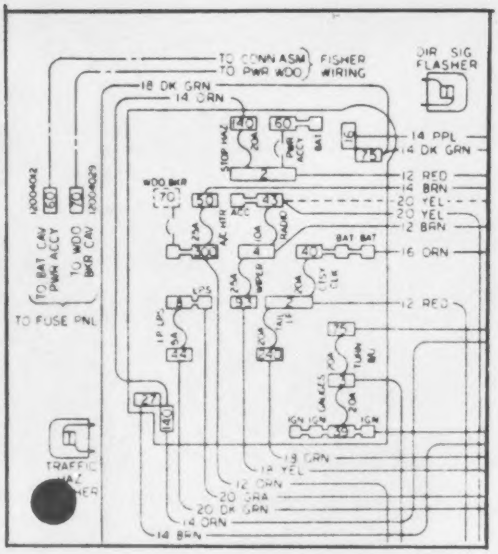
Circuit Identification Codes

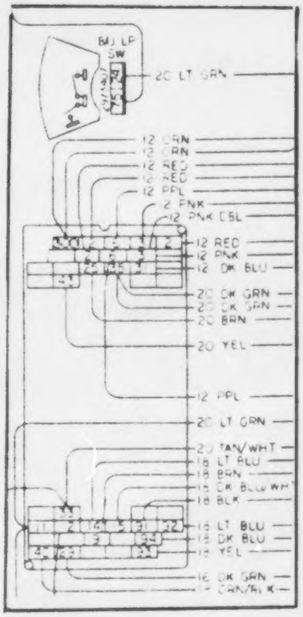
ELECTRICAL CIRCUIT IDENTIFICATION

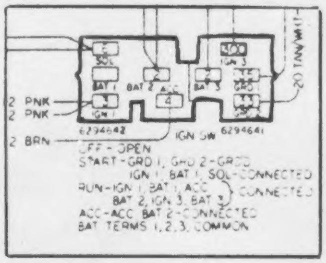
Circuit Number	Circuit Color	Circuit Name
2	Red	Feed, Battery - Unfused
3	Pink	Feed, Ign. Sw. "On" Controlled - Unfused
3	White,-Purple & Orange	Primary Ignition Voltage - Dropping Resistor. .38 ohm/ft.
3	White-Red & Black	Primary Ignition Voltage - Dropping Resistor 30 ohm./ft.
4	Brown	Feed. Ign. Sw. Accy. Controlled - Unfused
5	Purple	Neutral Safety Switch Feed or Neutral Safety Switch to Relay (Truck) or Relay to Ignition Switch (Truck) (Auto. Trans.)
6	Purple	Starter Solenoid Feed
7	Yellow	Primary Ignition Resistance Bypass
8	Gray	Instrument and Panel Lights, (Fused No. 44 Circuit)
9	Brown	Tail and License Lamp, Forward Side Marker Lamps Tail, Clearance and Marker Lamps (Trailers)
10	Light Blue	Dimmer Switch Feed
11	Light Green	Headlamp, High Beam
12	Tan	Headlamp, Low Beam
13	Purple	Front Parking Lamps
14	Light Blue	L.H. Indicator and Front Direction Light

Circuit Number	Circuit Color	Circuit Name
40	Orange	Feed, Battery - Fused
41	Brown-White	Feed, Ign. Sw. Accsy. Controlled - Fused
43	Yellow	Radio Feed
44	Dark Green	Instrument and Panel Lights, Feed (Usually Light Switch to Fuse)
45	Black	Marker and Clearance Lamps (Trailers - ICC Requirement)
46	Dark Blue	Rear Seat Speaker Feed from Radio Single or Rt., Stereo
47	Dark Blue	Auxiliary Circuits (Trailer)
49	Gray	Mod. Assembly to Control
50	Brown	Blower Switch - Feed
51	Yellow	Blower Feed - Low
52	Orange	Blower Feed - High
55	Orange	Kick-Down on Automatic Transmission
56	Tan	Amplifier to Heatsink (Radio)
59	Dark Green	Compressor to Air Conditioning Switch
60	Orange-Black	Feed, Battery - Circuit Breaker Protected
63	Tan	Blower-Switch Control - Low and Feed
65	Purple	Blower Motor to Relay
70	Red-White	Feed, Relay Controlled Circuit Breaker Protected


12004060
18 BLK
20 WHT
20 BLK
18 ORN
18 ORN
20 TAN
20 LT GRN
18 BRN
18 BRN
16 DK GRN
16 YEL
12004147
12004148
DIR SIG SW
14 WHT
16 DK GRN
16 YEL
14 PPL
14 BRN
18 DK BLU/WHT
18 DK BLU/WHT
18 LT BLU
18 LT BLU
20 BLK
ST LT SW
RT RR LP
LT RR LP
FLASHER
HAZ WARN
RT FRT LP
LT FRT LP
HORN
KEY ALARM
20 BLK/WHT
20 WHT

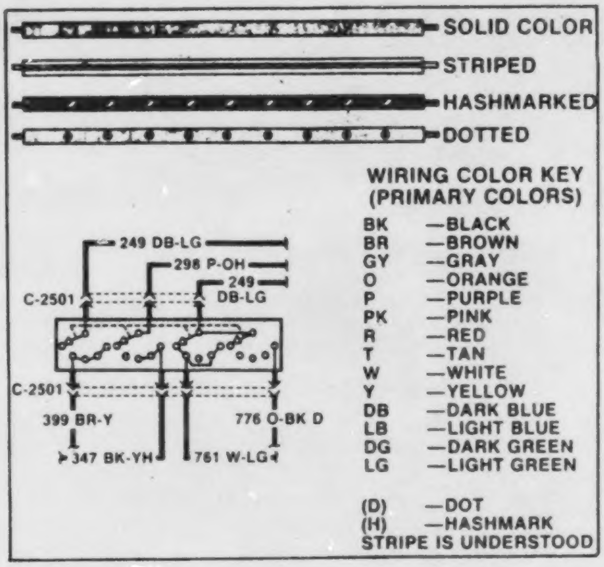

TO CONN ASM
TO PWR WDO
FISHER WIRING
DIR SIG FLASHER
18 DK GRN
14 ORN
12004012
12004029
TO BAT CAV PWR ACCY
TO WDO BKR CAV
TO FUSE PNL
WDO BKR
STOP HAZ
PWR ACCY
BAT
A/C HTR
ACC
RADIO
BAT BAT
WIPER
CTSY CLK
I P LPS
LPS
TAIL
GAGES
TURN B/U
IGN IGN
IGN
14 PPL
14 DK GRN
12 RED
14 BRN
20 YEL
20 YEL
12 BRN
16 ORN
12 RED
18 ORN
18 YEL
12 ORN
20 GRA
20 DK GRN
14 ORN
14 BRN
TRAFFIC HAZ FLASHER


B/U LP SW
20 LT GRN
12 ORN
12 ORN
12 RED
12 RED
12 PPL
12 PNK
12 PNK CSL
12 RED
12 PNK
12 DK BLU
20 DK GRN
20 DK GRN
20 BRN
20 YEL
12 PPL
20 LT GRN
20 TAN/WHT
18 LT BLU
18 BRN
18 DK BLU/WHT
18 BLK
18 LT BLU
18 DK BLU
18 YEL
16 DK GRN
18 ORN/BLK


SOL
BAT 1
BAT 2
ACC
BAT 3
IGN 3
GRD 1
GRD 2
IGN 1
20 TAN/WHT
2 PNK
2 PNK
2 BRN
6294642
IGN SW
6294641
OFF - OPEN
START - GRD 1, GRD 2 - GRD
IGN 1, BAT 1, SOL - CONNECTED
RUN - IGN 1, BAT 1, ACC
BAT 2, IGN 3, BAT 3
CONNECTED
ACC - ACC BAT 2 - CONNECTED
BAT TERMS 1, 2, 3, COMMON

Color Codes: Wires are color coded in one of four ways:

1. solid color
2. base color with stripe
3. base color with hashmark
4. base color with dot


SOLID COLOR
STRIPED
HASHMARKED
DOTTED
WIRING COLOR KEY
(PRIMARY COLORS)
BK —BLACK
BR —BROWN
GY —GRAY
O —ORANGE
P —PURPLE
PK —PINK
R —RED
T —TAN
W —WHITE
Y —YELLOW
DB —DARK BLUE
LB —LIGHT BLUE
DG —DARK GREEN
LG —LIGHT GREEN
(D) —DOT
(H) —HASHMARK
STRIPE IS UNDERSTOOD
249 DB-LG
298 P-OH
249 DB-LG
C-2501
C-2501
399 BR-Y
776 O-BK D
347 BK-YH
761 W-LG

CONDUCTOR IDENTIFICATION AND COLOR CODE

The most common wiring is either solid color or base color with a stripe. Color information may be found on the same charts with circuit codes and are always found next to each wire on the wiring diagram. Abbreviations for wire color, when used, are not standardized. Ford and Chrysler use one or two letter abbreviations while GM uses a three letter abbreviation. AMC and Mitchell Manuals print out the entire word. When reading abbreviations, use caution to follow the specific code for the diagram, i.e. Ford uses "p" to indicate purple while Chrysler uses "p" to indicate pink. Many General Motors diagrams are printed in full color with each wire correctly tinted to its color designation.

COLOR CODE			
BK	BLACK	P	PINK
BR	BROWN	R	RED
DBL	DARK BLUE	T	TAN
DGN	DARK GREEN	V	VIOLET
GY	GRAY	W	WHITE
LBL	LIGHT BLUE	Y	YELLOW
LGN	LIGHT GREEN	*	WITH TRACER
O	ORANGE		

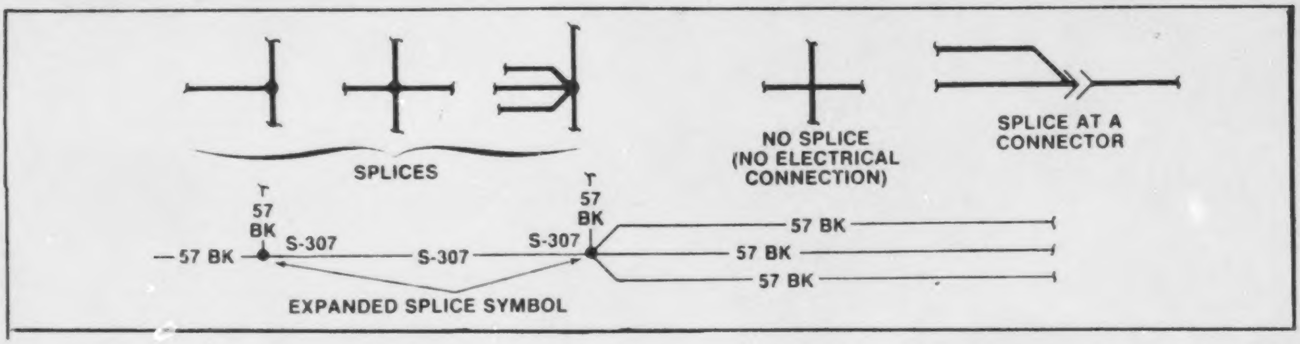
PK456

Wire Size:

Wire size can be a further aid in identifying and locating the wire in the vehicle. It can also aid in servicing when wire replacement is necessary. Chrysler, Ford and GM all present the wire gauge size information on the wire diagram. AMC and Mitchell Manuals do not. Motor's diagrams follow the manufacturers systems. For more information on wire gauge, see Electrical Competencies A-5, Information Sheet #3, Page 5.

Wire Splices and Circuit Ground

The wires shown on a wiring diagram are all part of a individual circuits which need a power source and a connecting point to ground. When circuits branch out to form parallel circuits, the branching point is called a"common point" since it now becomes a common power feed for the branches. In the chassis wiring system many branches are formed by splices within the wiring harness. When these splices are pictured on a wiring diagram, symbols are used. These splice symbols are standard to all types of diagrams.



Splice Symbols

Splices are indicated by a black dot where the wires are joined. If two wires cross and there is no black dot at the junction, there is no electrical connection where the wires cross on the diagram. Wires which are joined at a connector terminal do not have the splice symbol.

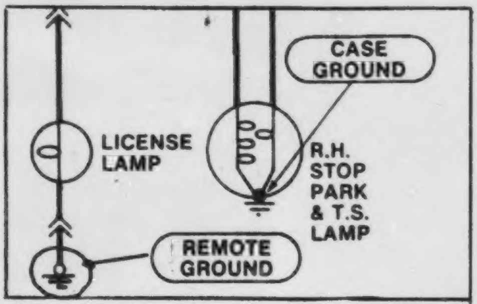
Expanded Splice Symbol

Where several conductors meet at the same splice, the splice symbol may be expanded to avoid cluttering up the diagram. As shown above, several wires are joined at S-307. The symbol, therefore, is drawn twice and connected by a line, also designated S-307. This line does not indicate a wire between two splices; there is only one splice S-307. Line S-307 is deawn only for schematic convenience and indicates a single splice.

Ground Symbols

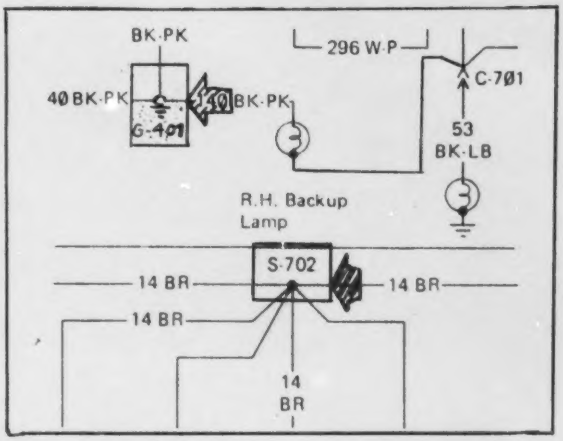
The standard ground symbol is used to indicate circuit grounds on a wiring diagram. Loads in a circuit may be grounded in either of two ways: through the case or remotely.

Case grounds are drawn connected to the component and may have a filled in circle on the symbol. A case ground indicates that the component is physically attached to a metal part of the vehicle.


CASE GROUND
LICENSE LAMP
R.H. STOP PARK & T.S. LAMP
REMOTE GROUND

Remote grounds are connected to the load by a wire. The symbol for a remote ground may have an open circle. The remote ground indicates that the component may be insulated from the chassis; or, in a position where the proper ground can not be achieved at all times.

On Ford wiring diagrams all harness splices and ground wire connections are coded. The code is referenced to a chart found elsewhere on the wiring diagram which gives splice location along with harness number and ground location.


BK-PK
296 W-P
40 BK-PK
40
BK-PK
C-701
G-401
53
BK-LB
R.H. Backup
Lamp
S-702
14 BR
14 BR
14 BR
14
BR

GROUND CODES	
G-302	IN 14401 ON INSTRUMENT PANEL
G-401	EYELET ON 14290 NEAR R.H. HEADLAMP
G-402	EYELET ON 14290 NEAR L.H. HEADLAMP
SPLICE CODES	
S-401	IN 14290 NEAR T/O TO GROUND EYELET
S-504	IN 14290 NEAR T/O TO L.H. FRONT SIDE MARKER LAMP
S-506	IN 14290 NEAR T/O TO L.H. FRONT SIDE MARKER LAMP

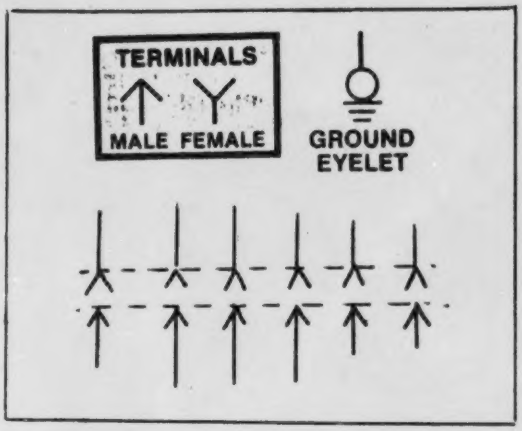
ELECTRICAL SYSTEMS 1976 MAVERICK & COMET
EXTERIOR LIGHTING

EFFECTIVE P.C.R.
SUPERSEDES
DATE

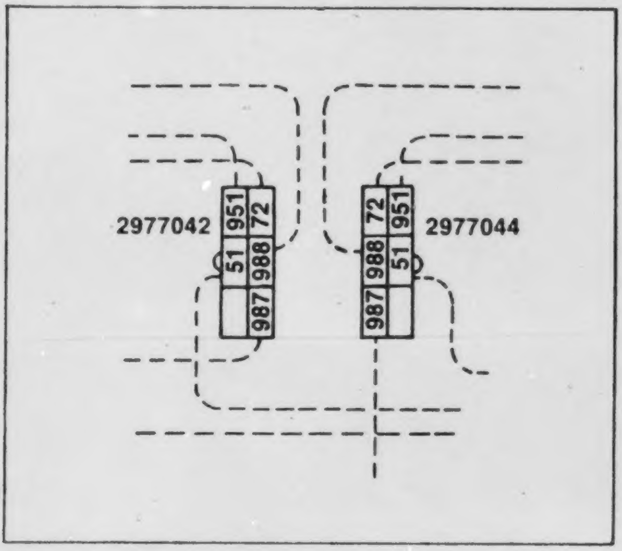
BEO ELECT INST MAN PAGE E60-705-4
SERVICE AND TRAINING MAN PAGE 4

Connectors

Connectors of several types are used to interconnect the electrical system wiring. Basically a connector is composed of one or more pair of terminal conductors molded into two connector halves. The figure below shows the standard symbol used for connectors. These are used by both Ford and Chrysler. On Ford diagrams the dotted line between terminal symbols indicates that all of the individual terminals are within a single connector shell.

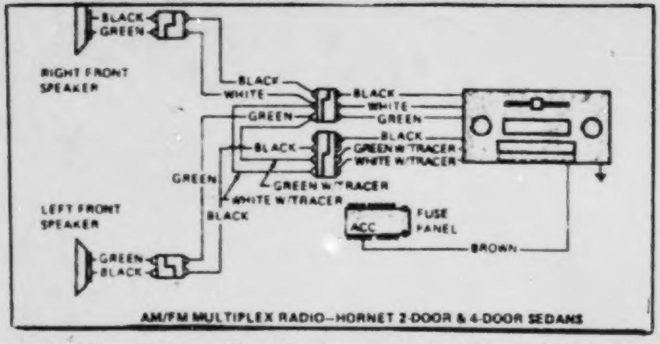


GM connector symbols are quite different from that of Ford or Chrysler. The figure below shos the GM symbol which is almost pictoral. The symbol incorporates the circuit numbers within the connector. Mitchell Manuals use similar symbols but without circuit markings

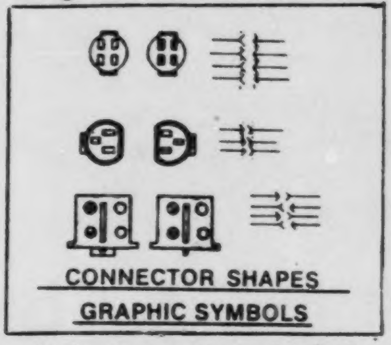


TYPICAL GM CONNECTOR SYMBOL

Pictorial connector symbols are used by American Motors (see figure below) and by Ford and Chrysler. While AMC includes the pictorial in the wiring diagram, Ford and Chrysler use the electrical symbol in the diagram with a reference code.

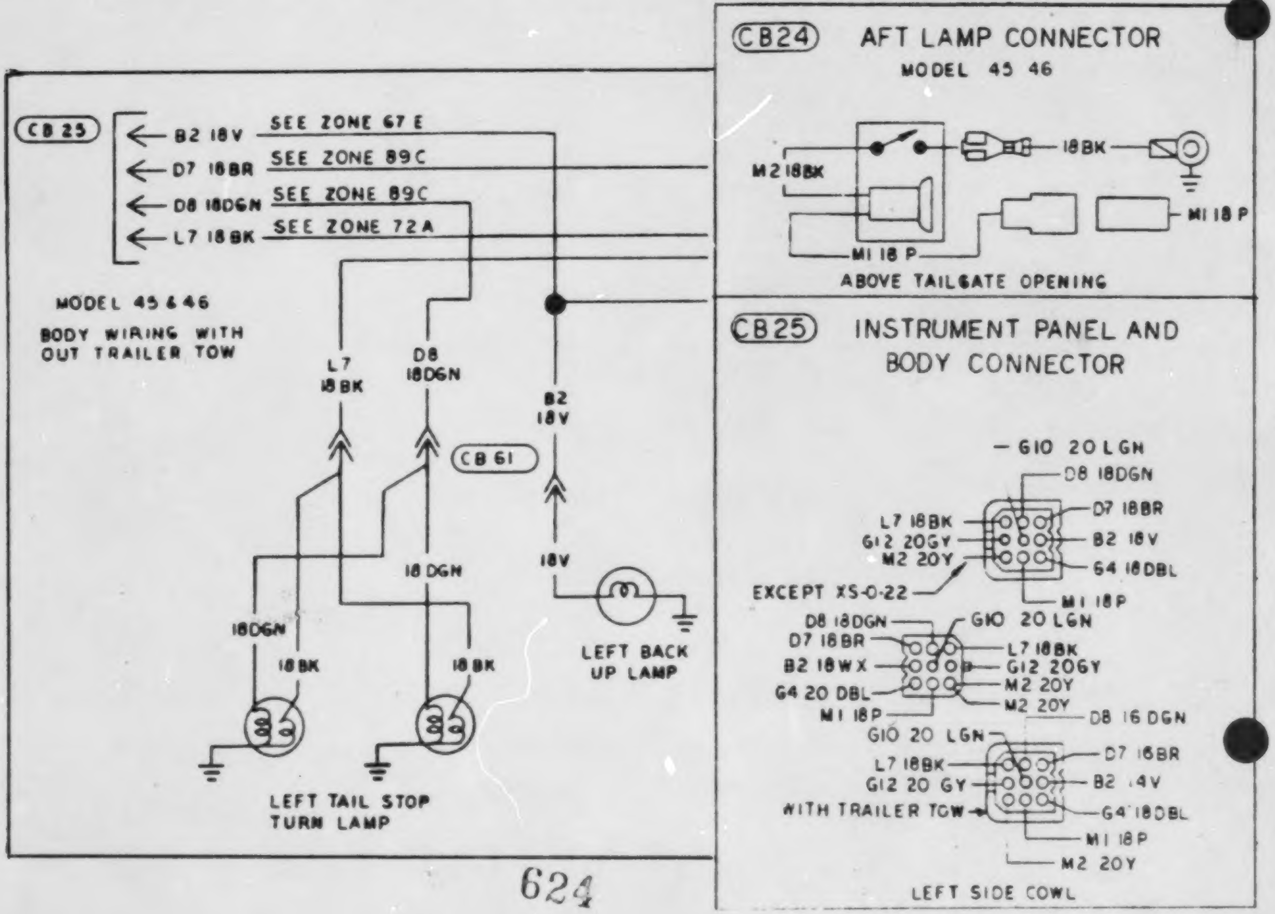

BLACK
GREEN
RIGHT FRONT SPEAKER
BLACK
WHITE
GREEN
BLACK
WHITE
GREEN
BLACK
GREEN W/TRACER
WHITE W/TRACER
BLACK
GREEN
GREEN W/TRACER
WHITE W/TRACER
BLACK
LEFT FRONT SPEAKER
ACC
FUSE PANEL
BROWN
GREEN
BLACK

AM/FM MULTIPLEX RADIO—HORNET 2-DOOR & 4-DOOR SEDANS


CONNECTOR SHAPES
GRAPHIC SYMBOLS

The reference code leads you to a detailed drawing of the connector which is printed elsewhere on the diagram chart. Along with the detail drawing showing connector shape, this section includes:
(a) location on the vehicle; (b) harness location or number; (c) part to which connector mates; (d) circuit numbers and colors of wires terminating in the connector (see figure below)

This system make the locating of test points much easier.

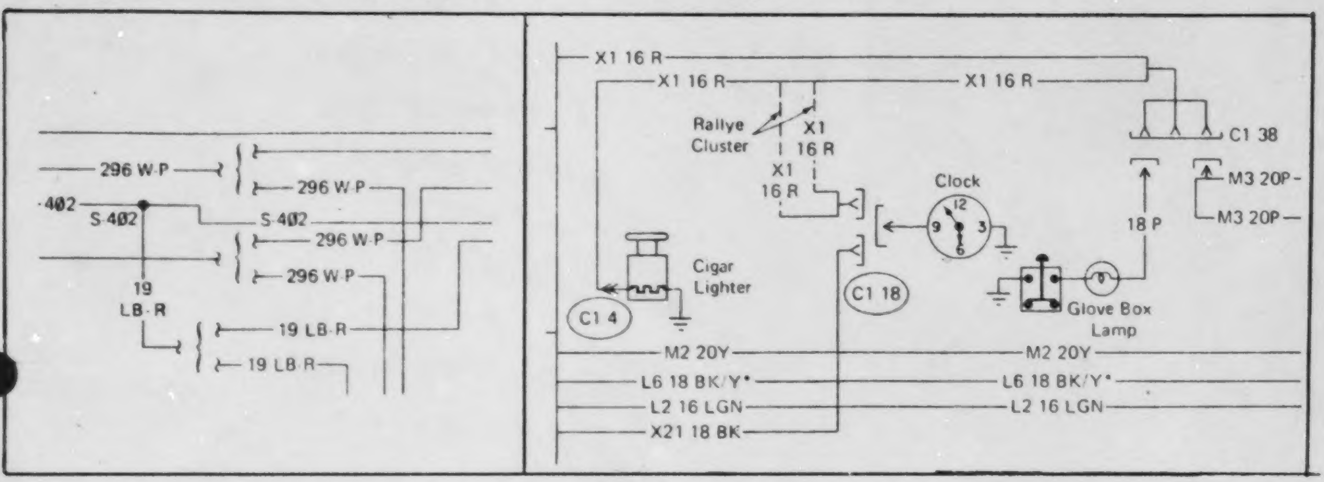

CB 25
B2 18V
SEE ZONE 67 E
D7 18BR
SEE ZONE 89C
D8 18DGN
SEE ZONE 89C
L7 18BK
SEE ZONE 72A
MODEL 45 & 46
BODY WIRING WITH OUT TRAILER TOW
L7 18BK
D8 18DGN
B2 18V
CB 61
18 DGN
18V
18DGN
18BK
18BK
LEFT BACK UP LAMP
LEFT TAIL STOP TURN LAMP
CB24
AFT LAMP CONNECTOR
MODEL 45 46
M2 18BK
18BK
M1 18 P
M1 18 P
ABOVE TAILGATE OPENING
CB25
INSTRUMENT PANEL AND BODY CONNECTOR
G10 20LGN
D8 18DGN
D7 18BR
B2 18V
G4 18DBL
M1 18P
L7 18BK
G12 20GY
M2 20Y
EXCEPT XS-0-22
D8 18DGN
G10 20LGN
D7 18BR
L7 18BK
B2 18WX
G12 20GY
G4 20 DBL
M2 20Y
M2 20Y
M1 18P
D8 16 DGN
G10 20 LGN
D7 16BR
L7 18BK
B2 14V
G12 20 GY
WITH TRAILER TOW
G4 18DBL
M1 18P
M2 20Y
LEFT SIDE COWL

Wire Connector Repair

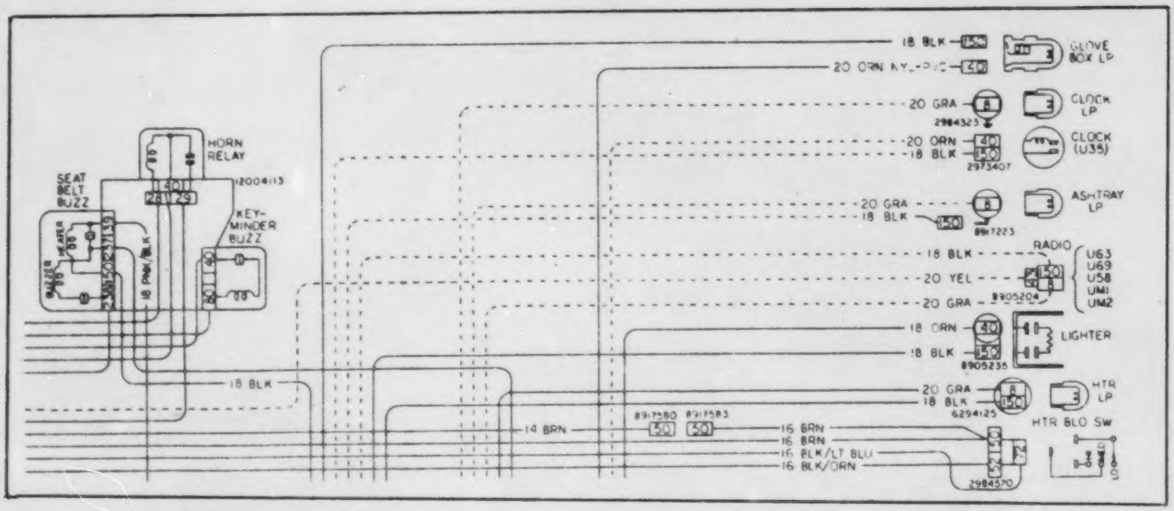
Repair of wire connectors may be necessary in the event of circuit malfunctions. The most common types of multiple connectors and their repair techniques were covered in Electrical Fundamental Competency A-8, Information Sheet #2.

Optional Wiring

Electrical components which are typically factory installed options are usually designated on the wiring diagram at the connector. The optional wiring is indicated by putting a bracket around the optional wires and pointing the bracket to the mating connector. See examples from Ford and Chrysler below.


296 W-P
402
S 402
S-402
296 W-P
296 W-P
296 W-P
19
LB-R
19 LB-R
19 LB-R
X1 16 R
X1 16 R
X1 16 R
Rallye
Cluster
X1
16 R
X1
16 R
Clock
12
9
3
6
C1 38
M3 20P
M3 20P
18 P
Cigar
Lighter
C1 18
C1 4
Glove Box
Lamp
M2 20Y
M2 20Y
L6 18 BK/Y*
L6 18 BK/Y*
L2 16 LGN
L2 16 LGN
X21 18 BK

Other techniques for showing optional wiring include the use of wavy line at the wire ends (above) or hash mark lines to illustrate the optional circuit such as GM below .


HORN
RELAY
12004113
SEAT
BELT
BUZZ
KEY-
MINDER
BUZZ
18 BLK
14 BRN
8917580
8917583
18 BLK
20 ORN
GLOVE
BOX LP
20 GRA
2984323
CLOCK
LP
20 ORN
18 BLK
2973407
CLOCK
(U35)
20 GRA
18 BLK
8917223
ASHTRAY
LP
18 BLK
20 YEL
20 GRA
8905204
RADIO
U63
U69
U58
UM1
UM2
18 ORN
18 BLK
8905235
LIGHTER
20 GRA
18 BLK
6294125
HTR
LP
HTR BLO SW
16 BRN
16 BRN
16 BLK/LT BLU
16 BLK/ORN
2984570

Electrical Symbols and Components

As discussed earlier, ground symbols are used on wiring diagrams to avoid the complicated and unnecessary practice of drawing conductors back to the negative side of the battery. Symbols are used throughout the wiring diagrams to represent various electrical components. Symbols are used because it is impractical and unnecessary to draw the components as they actually look. General Motors and Chrysler, however, do draw some components with representative shapes on their wiring diagrams.

Components

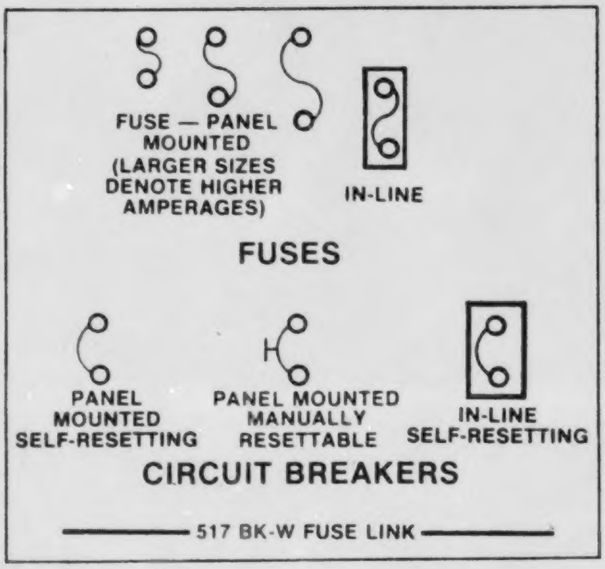
Basic electrical symbols were presented in the Electrical Fundamentals Competency A-5, Information Sheet #2. These basic symbols are for the most part common to the industry. The more complicated components however, require different typed of symbols or a collection of simple symbols to illustrate them. These component symbols are often developed by the manufacturer and thus will differ from one diagram to the other. The following discussion describes some of the more important components, their function, symbols, and designations.

Circuit Protection Devices

When overloads in a circuit cause too much current to flow, the wiring in the circuit will heat up, the insulation will melt, and a fire may result, unless the circuit has some sort of protection device. Devices such as fuses, fuse links, and circuit breakers are designed into circuits to provide protection from overloads.

Symbols and Designation

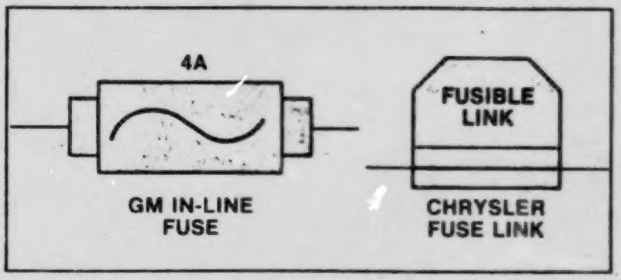
The symbols used on the wiring diagrams to designate circuit protection devices are shown below. Fuses and circuit breakers are designated on the diagrams by the letter "F" and number (F1, F2, etc.). Fuse link is designated by the circuit number and the words "FUSE LINK".


FUSE — PANEL MOUNTED (LARGER SIZES DENOTE HIGHER AMPERAGES)
IN-LINE
FUSES
PANEL MOUNTED SELF-RESETTING
PANEL MOUNTED MANUALLY RESETTABLE
IN-LINE SELF-RESETTING
CIRCUIT BREAKERS
517 BK-W FUSE LINK

FUSE, CIRCUIT BREAKER, AND FUSE LINK SYMBOLS

Related Information

The symbols for fuses and circuit breakers are fairly well standardized in the industry. Some differences exist in the manner in which in -line devices are drawn, however, as shown below.



TYPICAL GM AND CHRYSLER CIRCUIT PROTECTION SYMBOLS

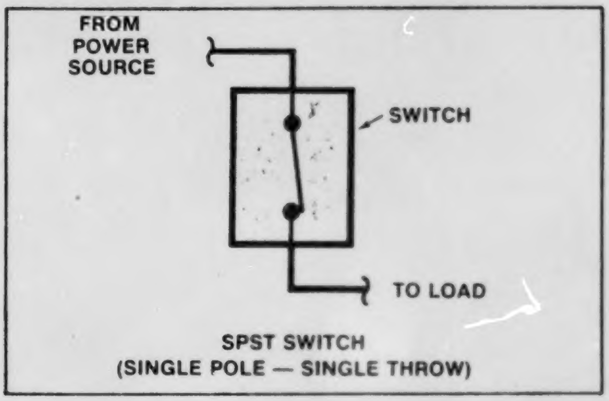
Switches

Electrical circuits in the electrical system are usually controlled by some sort of switch. Switches perform two primary functions: besides the simple ON/OFF function which controls current flow to various loads, switches may also direct the flow of current into various branches of circuits to coordinate the operation of electrical components according to different modes.

Terminology and Types

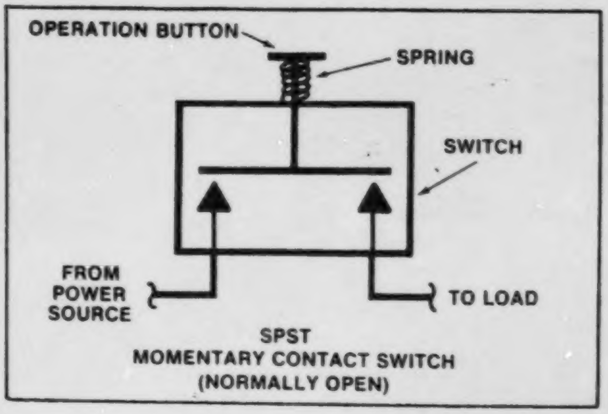
The ON/OFF function of switches is termed variously as OPEN/CLOSE or BREAK/MAKE.

A hinged-pawl switch is shown below. This is a single-pole single throw (SPST) hinged-pawl switch- the simplest type of switch. It makes/ breaks a single circuit. With this type of switch the circuit is either on or off. The term "pole" refers to the number of power (input) leads to the switch; the term "throw" refers to the number of output circuits made by the switch.



TYPICAL SPST, HINGED-PAWL SWITCH

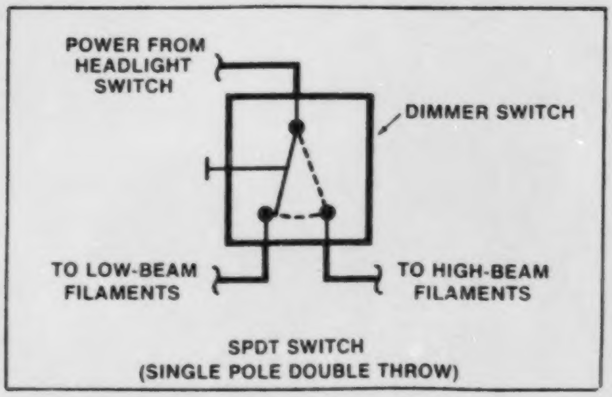
The next figure illustrates a push-pull type switch with momentary contacts. Again this is a single-pole single-throw switch. The spring-loaded feature of this switch keeps the contacts from "making" except when pressure is applied to its operating button.


OPERATION BUTTON
SPRING
SWITCH
FROM POWER SOURCE
TO LOAD
SPST
MOMENTARY CONTACT SWITCH
(NORMALLY OPEN)

TYPICAL SPST, NORMALLY OPEN, MOMENTARY CONTACT, PUSH-PULL SWITCH

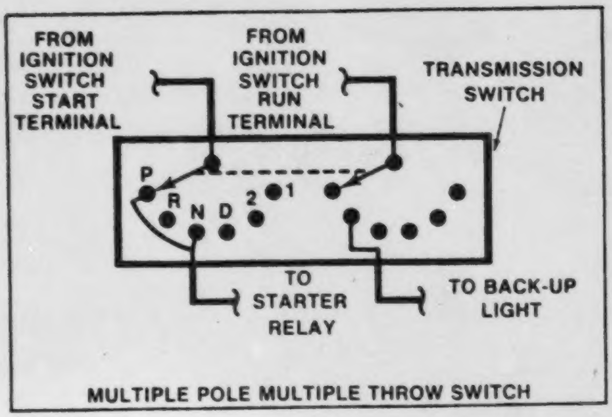
A horn switch is a good example of this type switch. Because the contacts of this switch are only closed when pressure is applied, this type of switch is referred to as "normally open". In applications where a spring load keeps the contacts closed except when pressure is applied, the switch is said to be "normally closed".

The figure below shows a single-pole double-throw (SPDT) hinged-pawl switch. With this switch, the single power source can feed either the high-beam or low-beam circuits.


POWER FROM HEADLIGHT SWITCH
DIMMER SWITCH
TO LOW-BEAM FILAMENTS
TO HIGH-BEAM FILAMENTS
SPDT SWITCH
(SINGLE POLE DOUBLE THROW)

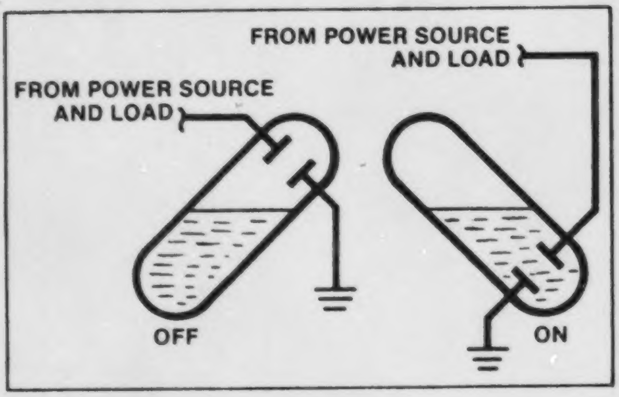
TYPICAL SPDT, HINGED-PAWL SWITCH

Switches can be designed, actually, with limitless numbers of poles and throws. The transmission switch shown in the next picture is a double-pole 6-throw switch, but is referred to as a multiple-pole multiple-throw switch. This switch can feed power to the starter relay in either P or N; in R it powers the backup lights. Note the dotted lines between the movable "wipers" of the switch. This dotted line indicates that the wipers are mechanically linked to move in unison. When the wipers are so linked, they are said to be "ganged".

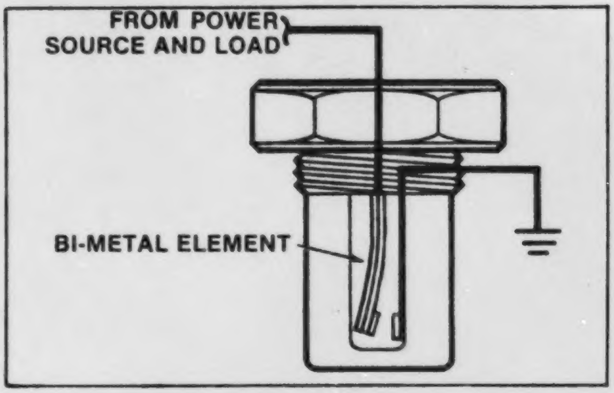

FROM IGNITION SWITCH START TERMINAL
FROM IGNITION SWITCH RUN TERMINAL
TRANSMISSION SWITCH
P
R
N
D
2
1
TO STARTER RELAY
TO BACK-UP LIGHT

MULTIPLE POLE MULTIPLE THROW SWITCH

Most switches in the electrical system are variations and combinations of hinged-pawl and push-pull switches with different numbers of poles and throws. There are, however, some special-type switches. The figure which follows illustrates a mercury switch. This special switch is used most often when a mechanical tilting action is made to activate a lighting circuit. Mercury switches are used in luggage compartment and engine compartment lighting systems, for example. The mercury switch is installed so that when the deck lid or hood is down, the mercury within the capsule is below the contacts. When the deck lid or hood is raised, the mercury switch is tilted, and the mercury makes a circuit between the switch contacts.


FROM POWER SOURCE AND LOAD
FROM POWER SOURCE AND LOAD
OFF
ON

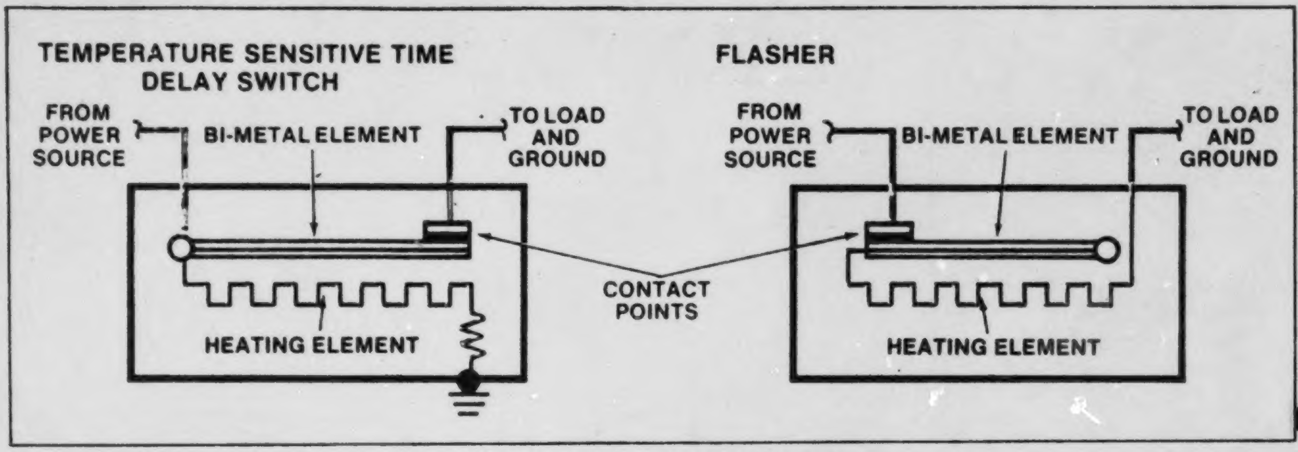
TYPICAL MERCURY SWITCH


FROM POWER SOURCE AND LOAD
BI-METAL ELEMENT

TYPICAL TEMPERATURE-SENSITIVE SWITCH

Another special-type switch is the temperature-sensitive switch in next picture. This switch has a bi-metallic element like a circuit breaker. This type switch is often used in an engine temperature warning system. Normally open, the bimetallic element bends the contacts closer together as temperature increases. Should the temperature of the engine exceed a preset limit, the contacts would close, completing a circuit to the engine-temperature warning light. Similar special-type switches are pressure-sensitive.

The figure below illustrates two different applications for heat-sensitive switches. A time-delay switch is normally closed. As current flows through the heating element the bi-metallic element warms up gradually until the contacts open. Even with the contacts open, however, current continues to flow through the heating element, keeping the bi-metallic element heated and the contacts open until power is shut off. The duration of the time delay can be varied by varying the resistance (and consequently, the current flow) in the heating element circuit.

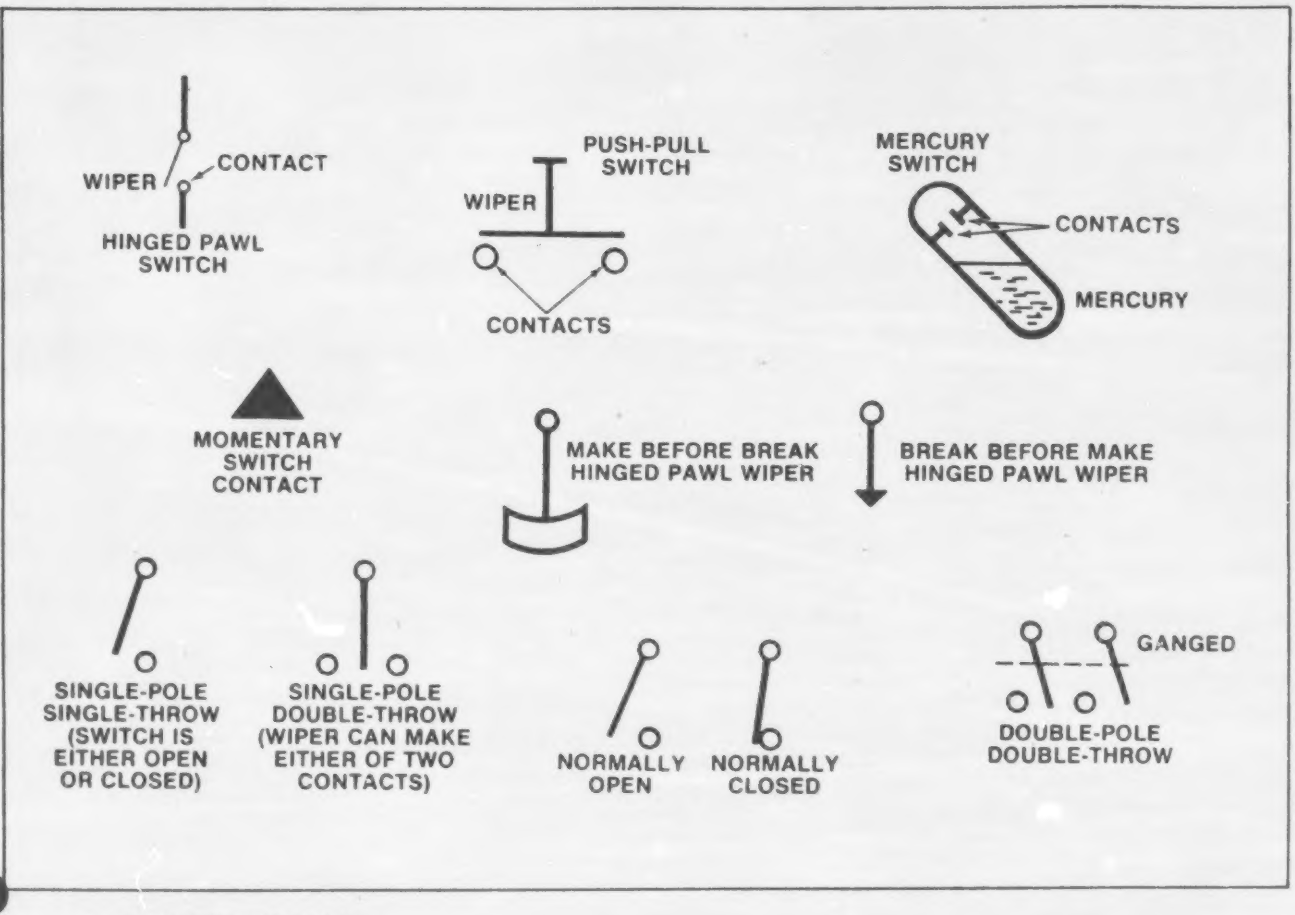

TEMPERATURE SENSITIVE TIME DELAY SWITCH
FROM POWER SOURCE
BI-METAL ELEMENT
TO LOAD AND GROUND
HEATING ELEMENT
FLASHER
FROM POWER SOURCE
BI-METAL ELEMENT
TO LOAD AND GROUND
CONTACT POINTS
HEATING ELEMENT

TEMPERATURE SENSITIVE SWITCHES USED AS TIME DELAY AND FLASHER

By putting the heating element in series with the bi-metallic element a temperature-sensitive switch becomes a flasher. In this arrangement, all current is shut off when the bi-metallic element opens. Then, because the elements cool, contact is soon re-established. This cycle is repeated quickly until power to the circuit is shut off.

Switch Symbols and Designation

The following picture illustrates the basic symbols used on Ford wiring diagrams. Two of the symbols deserve further explanation. The make-before-break wiper is used in multiple switches where it is necessary for the wiper, while being repositioned to make a circuit with an adjacent contact before the circuit with the previous contact is broken. The opposite is true for a break-before-make wiper. Both of these wipers are used in the ignition switch for example. No designation, such as S1, S2, etc., is used because the switch function is spelled out on the wiring diagram next to the switch symbol.
NOTE: Both Chrysler and GM use switch symbols that are similar to those used by Ford.

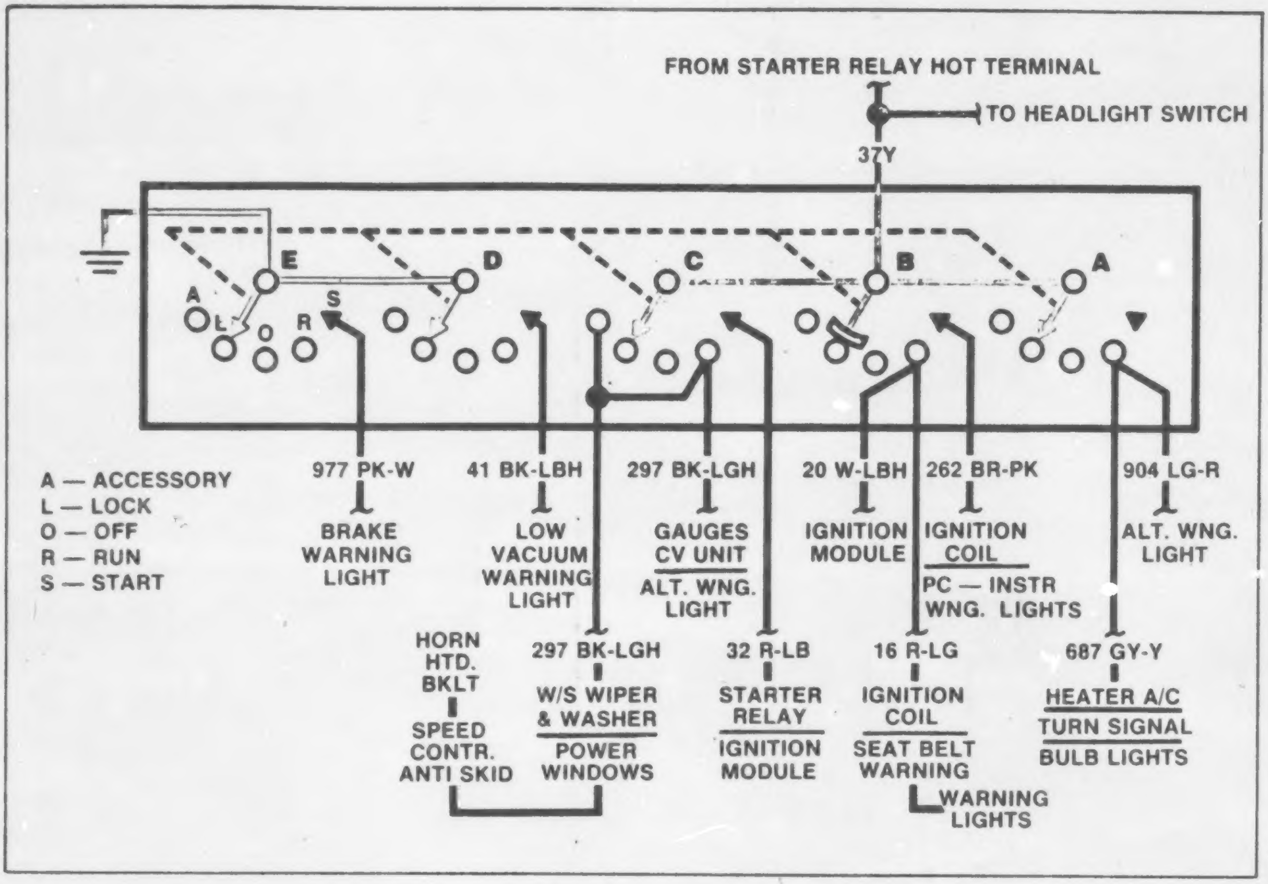

WIPER
CONTACT
HINGED PAWL SWITCH
PUSH-PULL SWITCH
WIPER
CONTACTS
MERCURY SWITCH
CONTACTS
MERCURY
MOMENTARY SWITCH CONTACT
MAKE BEFORE BREAK HINGED PAWL WIPER
BREAK BEFORE MAKE HINGED PAWL WIPER
SINGLE-POLE SINGLE-THROW (SWITCH IS EITHER OPEN OR CLOSED)
SINGLE-POLE DOUBLE-THROW (WIPER CAN MAKE EITHER OF TWO CONTACTS)
NORMALLY OPEN
NORMALLY CLOSED
GANGED
DOUBLE-POLE DOUBLE-THROW

BASIC SWITCH SYMBOLS

Special Switches

Two switches deserve special attention because of their complexity and importance- the ignition switch and the headlight switch.

The ignition switch is the control for all circuits that operate only in certain vehicle operating modes (START, RUN, ACCESSORY). The switch has five ganged segments. Circuits on Ford wiring diagrams are designated by circuit numbers. The lower figure summarizes the circuits controlled by the different segments in the different switch positions.


FROM STARTER RELAY HOT TERMINAL
TO HEADLIGHT SWITCH
37Y
E
D
C
B
A
A
L
O
R
S
A — ACCESSORY
L — LOCK
O — OFF
R — RUN
S — START
977 PK-W
BRAKE WARNING LIGHT
41 BK-LBH
LOW VACUUM WARNING LIGHT
297 BK-LGH
GAUGES CV UNIT
ALT. WNG. LIGHT
20 W-LBH
IGNITION MODULE
262 BR-PK
IGNITION COIL
PC — INSTR WNG. LIGHTS
904 LG-R
ALT. WNG. LIGHT
HORN HTD. BKLT
SPEED CONTR. ANTI SKID
297 BK-LGH
W/S WIPER & WASHER
POWER WINDOWS
32 R-LB
STARTER RELAY
IGNITION MODULE
16 R-LG
IGNITION COIL
SEAT BELT WARNING
WARNING LIGHTS
687 GY-Y
HEATER A/C
TURN SIGNAL
BULB LIGHTS

TYPICAL IGNITION SWITCH

SWITCH POSITION	CIRCUITS FED BY SWITCH SEGMENTS				
	E	D	C	B	A
ACC			297		
LOCK					
OFF					
RUN			297	20, 16	687, 904
START	977	41	32	262	

CIRCUITS ACTIVATED IN VARIOUS IGNITION SWITCH POSITIONS

-Segments A,B, and C receive power through circuit 37.
-Segments D and E connect their respective circuits to ground.
-In ACC, certain accessories and gauges are fed power through segment C.
-In LOCK and OFF, no circuits are supplied power through the ignition switch.
-In RUN, segment C supplies power to certain accessories and gauges, just as in ACC.

Segment B supplies power to the ignition moduls, ignition coil, and seat-belt warning devices, and other warning lights. (These warning devices will not operate, however, unless their individual switches are closed). Segment A supplies power to certain accessories and the alternator warning light.

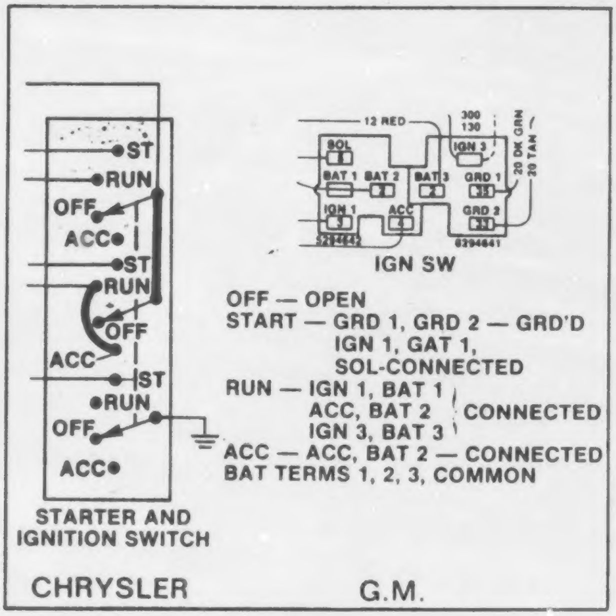
-In START, the brake and low-vacuum warning circuits are completed to ground through segments E and D respectively. The starter relay is energized through segment C. The ignition coil is kept energized through segment B. The instrument warning lights are also enabled through segment B.

Note that in START, the brake and low-vacuum warning lights will come on the prove out that they operate. Because the contacts in the START position are momentary, after the engine starts, the ignition switch returns to RUN.

In Run, these warning lights will go out unless a warning condition exists, in which case an alternate path to ground is completed.

Note also the wiper in segment B. This ia a make-before-break wiper, used to provide continuity of power to the ignition coil in switching from RUN to START and back to RUN.

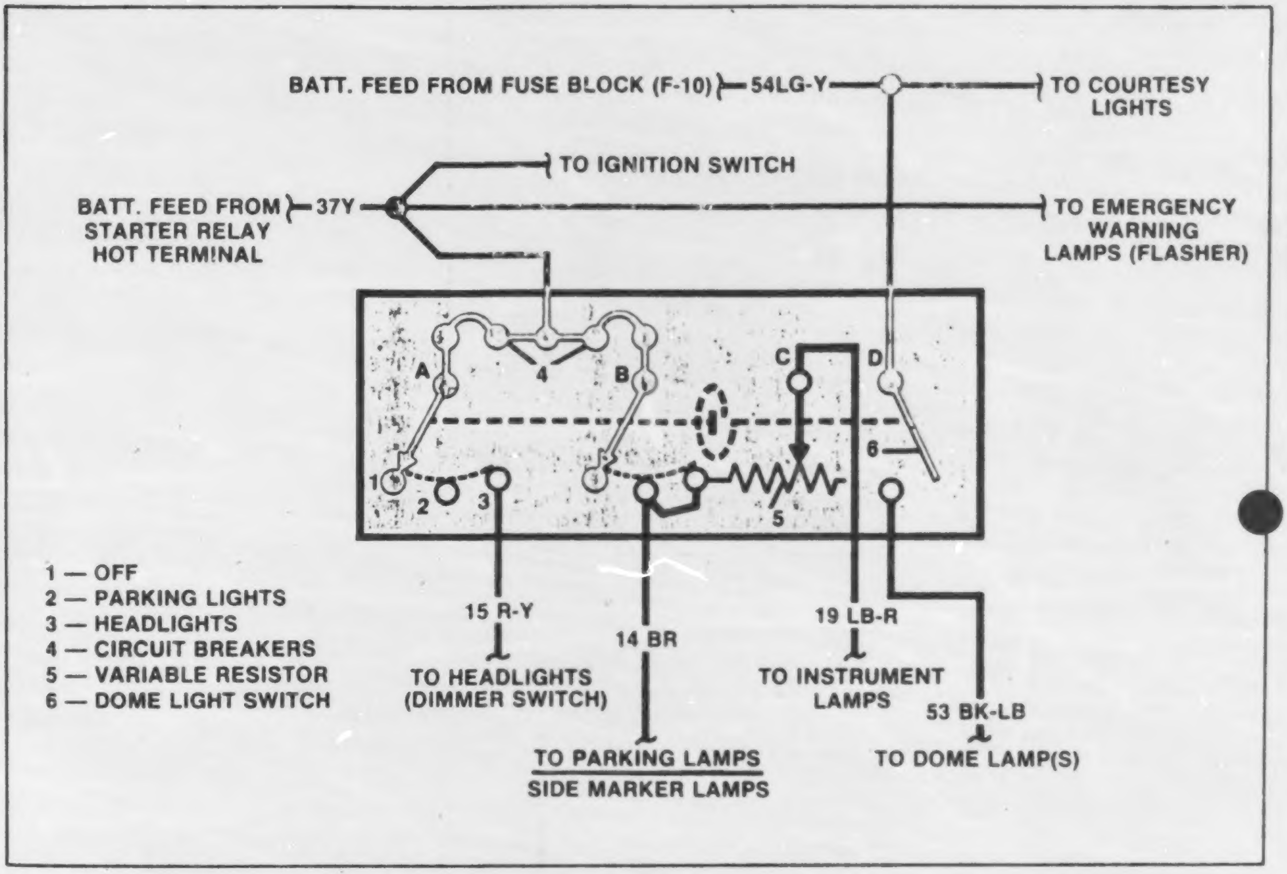
On Chrysler wiring diagrams the ignition switch is different but represented similarly. On GM diagrams the ignition switch is drawn entirely differently.


ST
RUN
OFF
ACC
ST
RUN
OFF
ACC
ST
RUN
OFF
ACC
STARTER AND IGNITION SWITCH
12 RED
300
130
20 DK GRN
20 TAN
SOL
IGN 3
BAT 1
BAT 2
BAT 3
GRD 1
IGN 1
ACC
GRD 2
6294642
6294641
IGN SW
OFF — OPEN
START — GRD 1, GRD 2 — GRD'D
IGN 1, GAT 1,
SOL-CONNECTED
RUN — IGN 1, BAT 1
ACC, BAT 2
IGN 3, BAT 3
CONNECTED
ACC — ACC, BAT 2 — CONNECTED
BAT TERMS 1, 2, 3, COMMON
CHRYSLER
G.M.

TYPICAL CHRYSLER AND GM IGNITION SWITCH

The headlight switch shown below is another multiple-ganged- segmented switch. All headlights, parking lights, marker lights, instrument lights, and dome lights are supplied by this switch.

The second picture summarizes the various circuits supplied by different segments in different switch positions.


BATT. FEED FROM FUSE BLOCK (F-10)
54LG-Y
TO COURTESY LIGHTS
TO IGNITION SWITCH
BATT. FEED FROM STARTER RELAY HOT TERMINAL
37Y
TO EMERGENCY WARNING LAMPS (FLASHER)
A
4
B
C
D
6
1
2
3
5
15 R-Y
TO HEADLIGHTS (DIMMER SWITCH)
14 BR
TO PARKING LAMPS
SIDE MARKER LAMPS
19 LB-R
TO INSTRUMENT LAMPS
53 BK-LB
TO DOME LAMP(S)
1 — OFF
2 — PARKING LIGHTS
3 — HEADLIGHTS
4 — CIRCUIT BREAKERS
5 — VARIABLE RESISTOR
6 — DOME LIGHT SWITCH

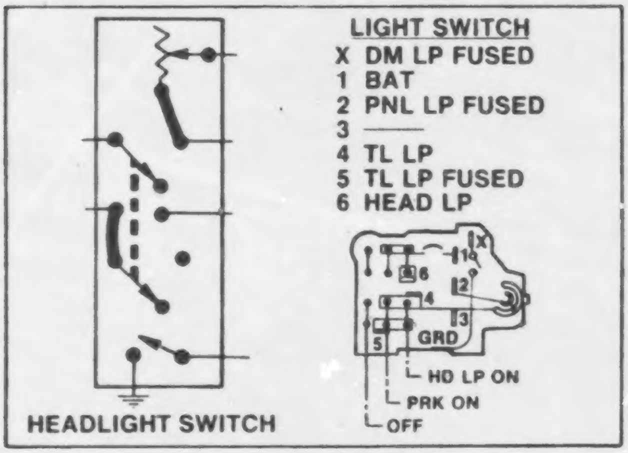
TYPICAL HEADLIGHT SWITCH

SWITCH POSITION	CIRCUITS POWERED BY SEGMENTS			
	A	B	C	D
OFF (SWITCH IN)				
PARK LIGHTS (SWITCH HALF-WAY OUT)		14	19	
ON (SWITCH OUT)	15	14	19	
DOME LIGHT (SWITCH PAST FULL BRIGHT)				53

CIRCUITS POWERED BY VARIOUS SEGMENTS IN DIFFERENT HEADLIGHT SWITCH POSITIONS

- Segments A,B, and C are powered by circuit 37, through individual circuit breakers.
- Segment D is powered by circuit 54.
- In OFF, no circuits are fed power through the headlight switch.
- In PARK LIGHT, when the switch is half-way out, the parking lamps, sidemarker lamps, and instrument panel lamps receive power through segment B.
- In ON, the same lamps receive power as in PARK LIGHT, through segment B, and the headlights also receive power through segment A.
- In PARK LIGHT and ON, the switch can be rotated to vary the panel illumination intensity by means of the variable resistor between segments C and D.
- In DOME LIGHT, when the illumination intensity control is turned beyond full bright, curcuit 53 receives power through segment D.

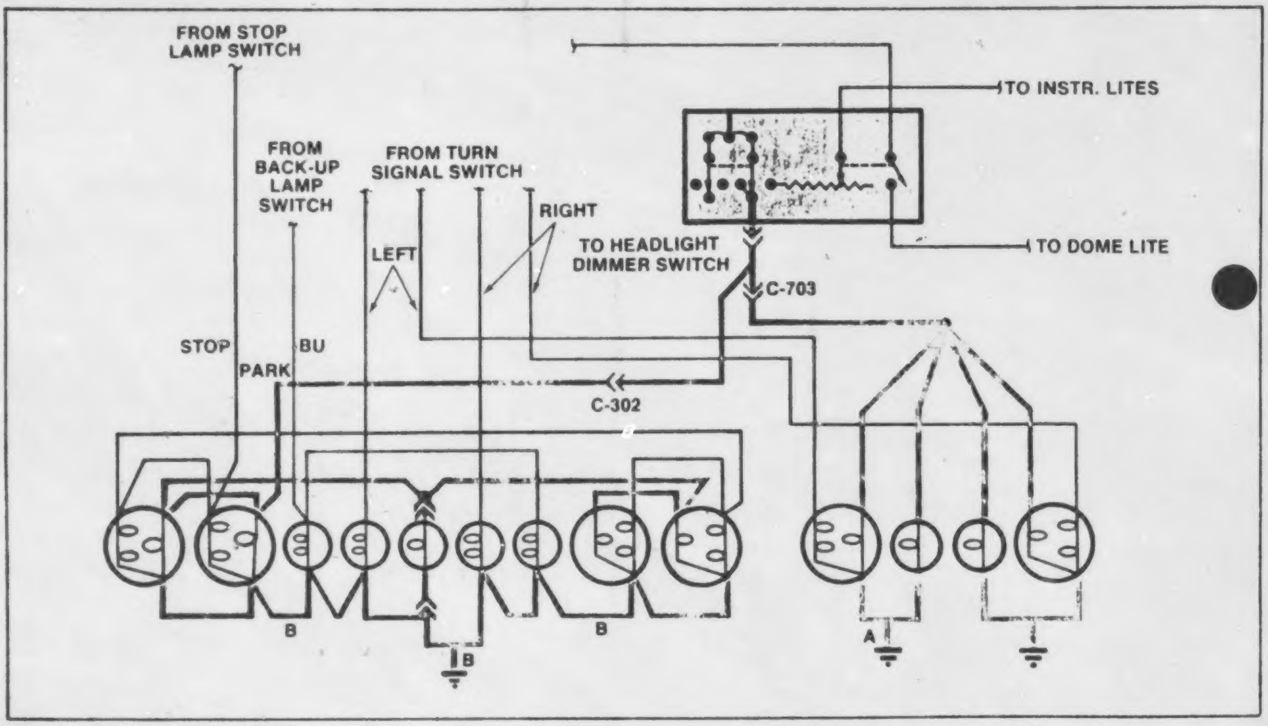
As with the ignition switch, the Chrysler symbol for the headlight switch on their wiring diagrams is similar to the Ford symbol. The GM symbol is entirely different.


HEADLIGHT SWITCH
LIGHT SWITCH
X DM LP FUSED
1 BAT
2 PNL LP FUSED
3 ——
4 TL LP
5 TL LP FUSED
6 HEAD LP
X
1
2
3
4
5
6
GRD
HD LP ON
PRK ON
OFF

TYPICAL CHRYSLER AND GM HEADLIGHT SWITCH SYMBOLS

Switch Position in Diagnosis

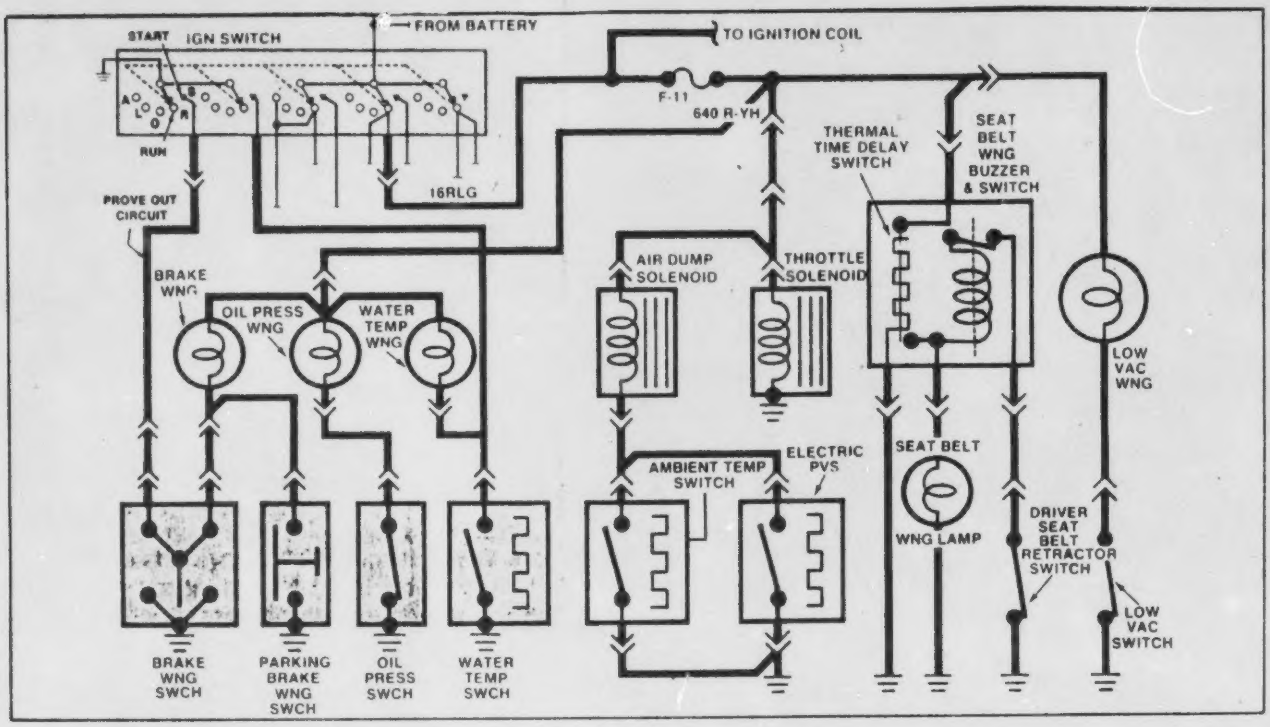
Knowing the position of the switch (or switches) in a circuit can give you much information in diagnosis. By referring to the wiring diagrams you could tell that in the circuit shown below, the circuit has the switch between the power source and the load. This type of circuit is uaually the easiest type to diagnose, because when the switch is closed all points between the power source and the load should be at source voltage. A no-voltage reading at any load indicates an open circuit between the source and the load. In this circuit a short would cause the parking lights circuit breaker to open. By separating the circuit into simpler circuits as described under "DIAGNOSIS", you can quickly find either a short or open.



TYPICAL EXAMPLE OF CIRCUIT WITH SWITCH BETWEEN POWER SOURCE AND LOAD

The following picture shows a circuit with the switch between load and ground. Such an arrangement is often used to connect warning lights. This circuit has its own significant characteristic: when the switch is open, there will normally be full source voltage on both sides of the load and at all other points between the source and switch. A no-voltage reading at any point on the source side of the switch indicates an open between that point and the source.

Warning lamps which come on and remain on, indicate a short between the lamp and the switch or a shorted switch.


START
IGN SWITCH
FROM BATTERY
TO IGNITION COIL
RUN
F-11
640 R-YH
16RLG
PROVE OUT CIRCUIT
THERMAL TIME DELAY SWITCH
SEAT BELT WNG BUZZER & SWITCH
BRAKE WNG
OIL PRESS WNG
WATER TEMP WNG
AIR DUMP SOLENOID
THROTTLE SOLENOID
LOW VAC WNG
SEAT BELT WNG LAMP
AMBIENT TEMP SWITCH
ELECTRIC PVS
DRIVER SEAT BELT RETRACTOR SWITCH
LOW VAC SWITCH
BRAKE WNG SWCH
PARKING BRAKE WNG SWCH
OIL PRESS SWCH
WATER TEMP SWCH

TYPICAL CIRCUITS WITH SWITCH BETWEEN LOAD AND GROUND

Note that the air dump solenoid may be controlled by either of two switches.

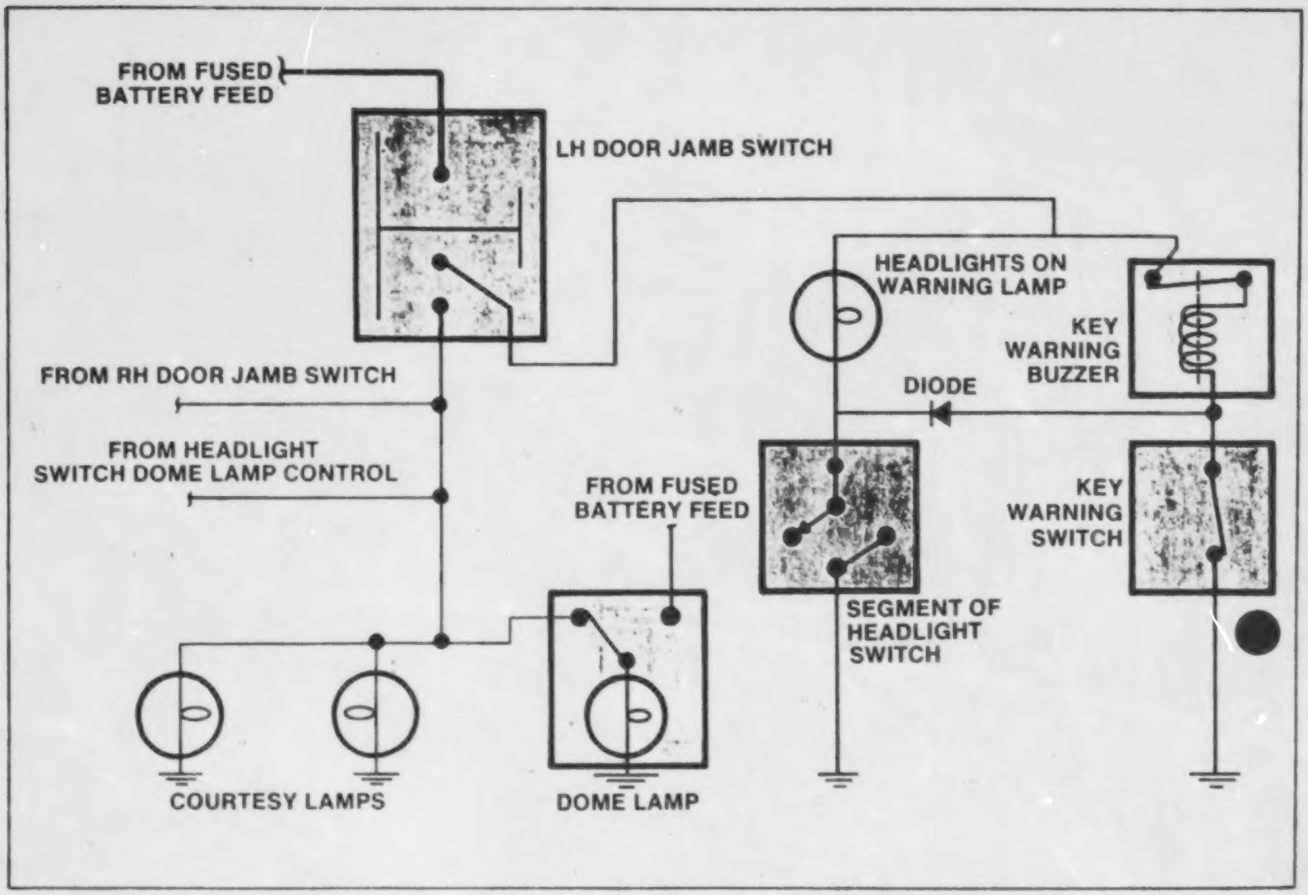
Note also the "prove out" circuit for the brake and engine temperature warning lights. When the ignition switch is in START these lamps will be on. These circuits are provided to verify that the lamps work. In RUN, the lamps go out, unless their warning switches are closed.

The normally closed switches for the oil-pressure and low-vacuum warning lights prove out automatically in RUN before the engine is started. These lights go out in RUN after the engine is started.

If a lamp will not go out, there may be a short in the prove-out circuit.

The following picture shows a switch controlling multiple loads. In this circuit all conductors are hot whenever the LH door jamb switch is closed (door open). Part of the circuit (courtesy and dome lamps) will be hot when the RH door is open. The key and headlights on warning circuits will not be hot when the RH door is open.

Even though the key and headlight warning circuits are hot when the LH door jamb switch is closed, the circuits will not function unless their respective switches are also closed. By studying the wiring diagram, the cause/effect of opens and shorts in the circuit can be diagnosed.

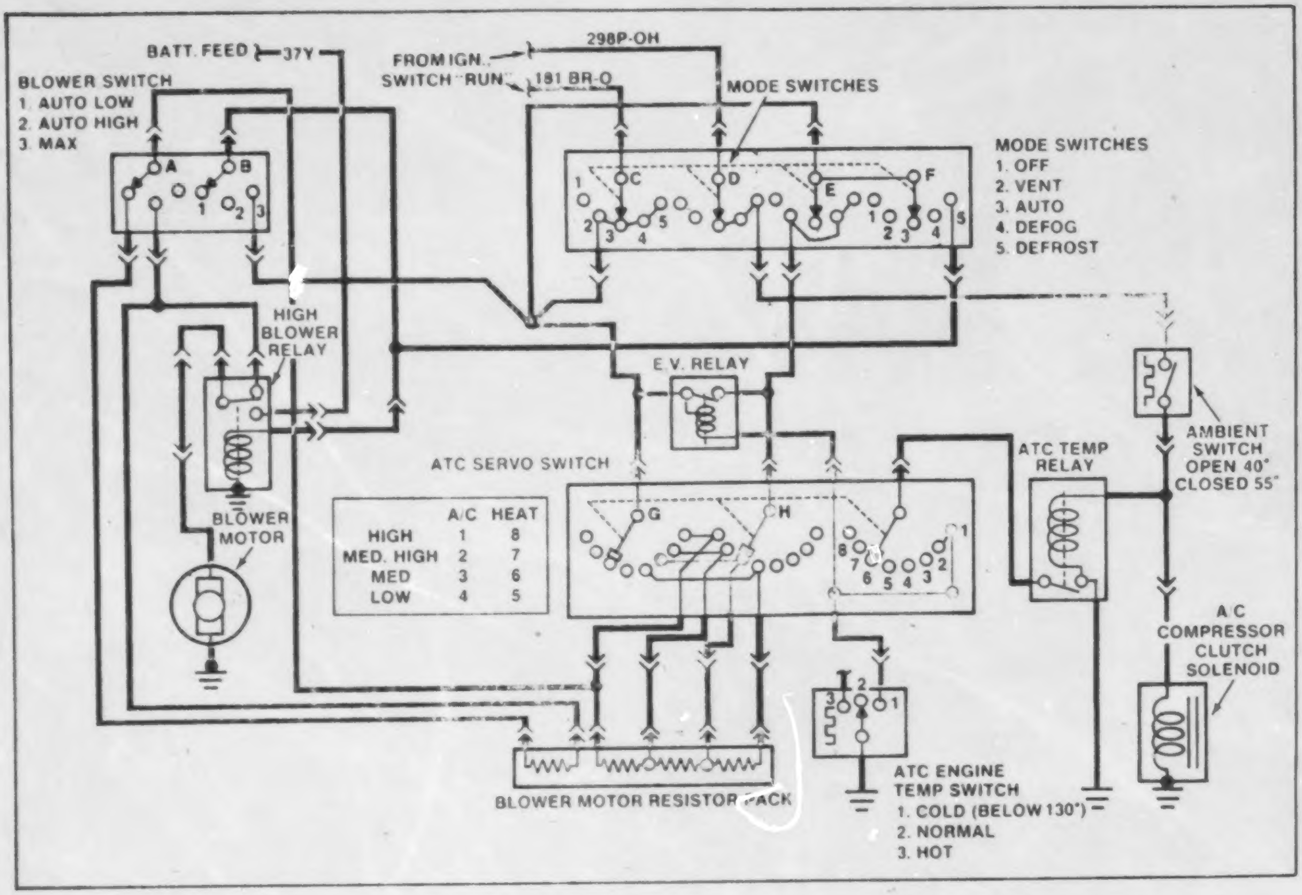

FROM FUSED BATTERY FEED
LH DOOR JAMB SWITCH
HEADLIGHTS ON WARNING LAMP
KEY WARNING BUZZER
DIODE
FROM RH DOOR JAMB SWITCH
FROM HEADLIGHT SWITCH DOME LAMP CONTROL
FROM FUSED BATTERY FEED
KEY WARNING SWITCH
SEGMENT OF HEADLIGHT SWITCH
COURTESY LAMPS
DOME LAMP

TYPICAL CIRCUIT WITH SWITCH CONTROLLING MULTIPLE LOADS

The following picture shows a circuit with multiple switches. There are only two key loads in this circuit, the blower motor and the A/C compressor clutch solenoid. The five switches and three relays control various operations of the two key loads.

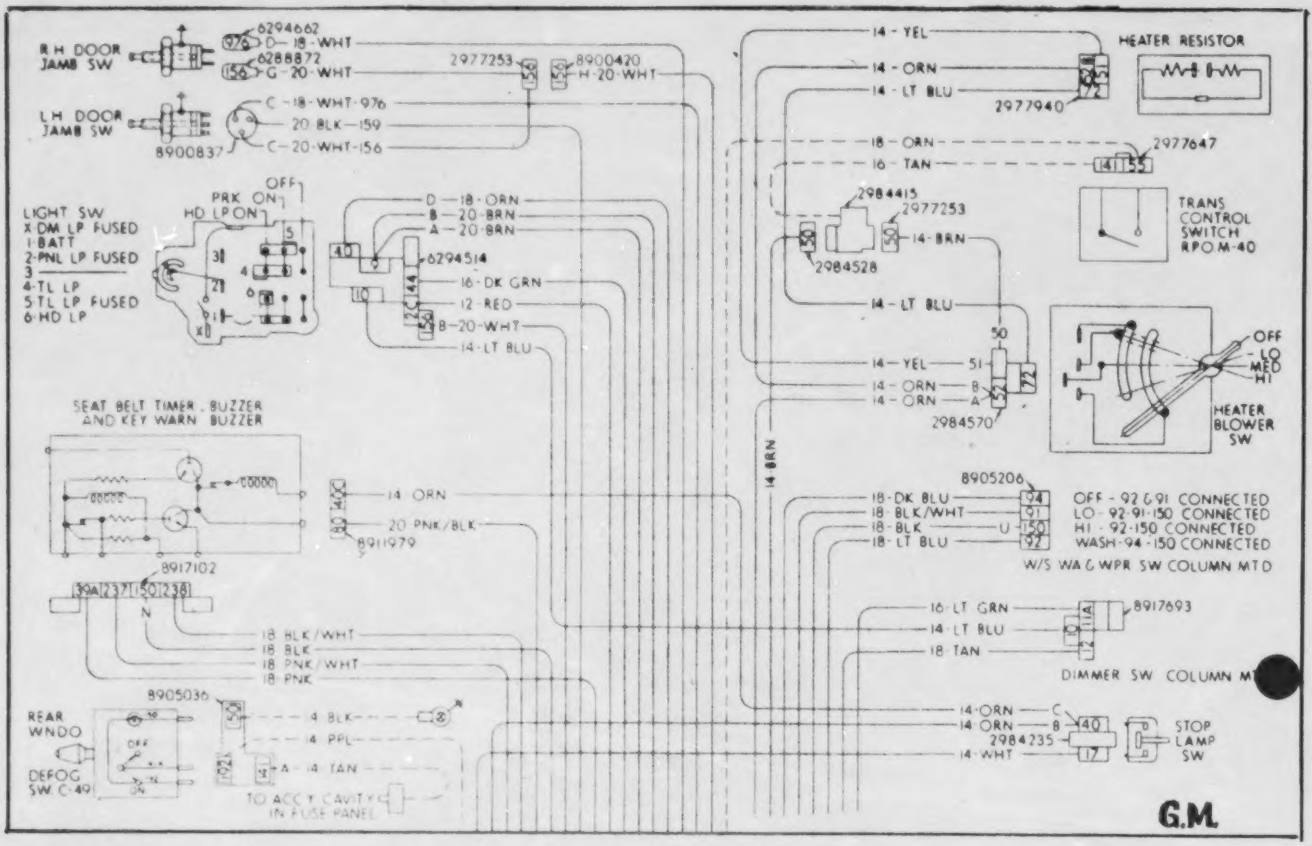
A full explanation of this circuit's operation in all modes is too lengthy to include here. Just remember when diagnosing problems in this type circuit to take into account all factors governing the circuit, such as:
-The actual state of temperature-sensitive switches
-The position of all manual switches
-The position of relays
-The circuits connected to common points

In other words, refer to the diagrams to determine which portions of the circuit are hot and which are not. This determination is explained further under "Wiring Diagrams".


BATT. FEED
37Y
FROM IGN. SWITCH "RUN"
298P-OH
181 BR-O
BLOWER SWITCH
1. AUTO LOW
2. AUTO HIGH
3. MAX
A
B
1
2
3
MODE SWITCHES
C
D
E
F
1
2
3
4
5
MODE SWITCHES
1. OFF
2. VENT
3. AUTO
4. DEFOG
5. DEFROST
HIGH BLOWER RELAY
E.V. RELAY
BLOWER MOTOR
ATC SERVO SWITCH
A/C HEAT
HIGH 1 8
MED. HIGH 2 7
MED 3 6
LOW 4 5
G
H
ATC TEMP RELAY
AMBIENT SWITCH OPEN 40° CLOSED 55°
A/C COMPRESSOR CLUTCH SOLENOID
BLOWER MOTOR RESISTOR PACK
ATC ENGINE TEMP SWITCH
1. COLD (BELOW 130°)
2. NORMAL
3. HOT

TYPICAL CIRCUIT WITH MULTIPLE SWITCHES -- FORD

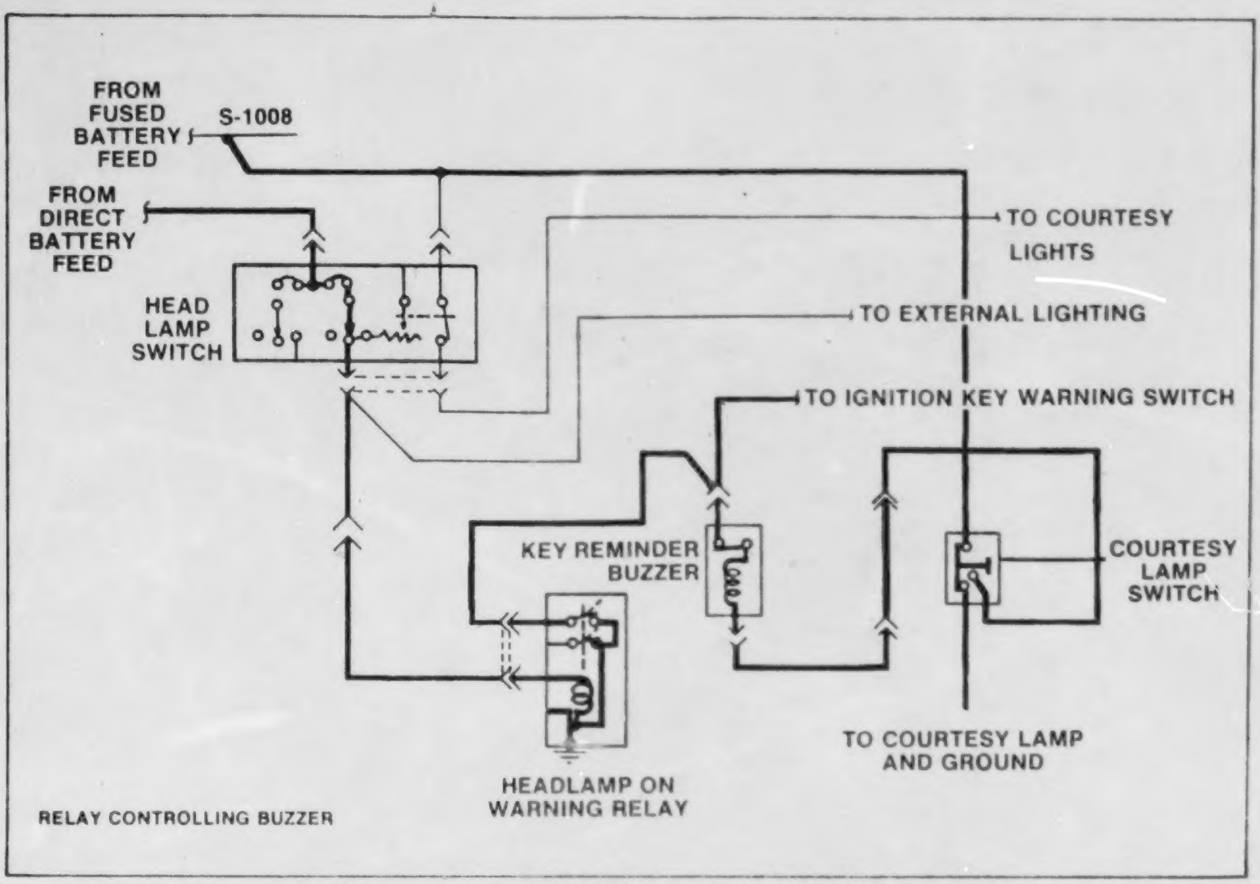
The figure at the top of the next page shows a GM diagram illustrating several switches.


R H DOOR JAMB SW
L H DOOR JAMB SW
6294662
6288872
8900837
976 D - 18 - WHT
156 G - 20 - WHT
C - 18 - WHT - 976
20 BLK - 159
C - 20 - WHT - 156
2977253
8900420
H - 20 - WHT
LIGHT SW
X-DM LP FUSED
1-BATT
2-PNL LP FUSED
3
4-TL LP
5-TL LP FUSED
6-HD LP
PRK ON
HD LP ON
OFF
D - 18 - ORN
B - 20 - BRN
A - 20 - BRN
6294514
16 - DK GRN
12 - RED
B - 20 - WHT
14 - LT BLU
SEAT BELT TIMER, BUZZER AND KEY WARN BUZZER
14 ORN
20 PNK/BLK
8911979
8917102
18 BLK/WHT
18 BLK
18 PNK/WHT
18 PNK
8905036
REAR WNDO DEFOG SW. C-49
14 BLK
14 PPL
A - 14 TAN
TO ACC'Y CAVITY IN FUSE PANEL
14 - YEL
14 - ORN
14 - LT BLU
HEATER RESISTOR
2977940
18 - ORN
16 - TAN
2977647
2984415
2977253
14 - BRN
2984528
TRANS CONTROL SWITCH RPO M-40
14 - LT BLU
50
14 - YEL
51
14 - ORN - B
14 - ORN - A
2984570
OFF
LO
MED
HI
HEATER BLOWER SW
14 BRN
8905206
18 - DK BLU
18 - BLK/WHT
18 - BLK
U
18 - LT BLU
OFF - 92 & 91 CONNECTED
LO - 92-91-150 CONNECTED
HI - 92-150 CONNECTED
WASH - 94 - 150 CONNECTED
W/S WA & WPR SW COLUMN MTD
16 - LT GRN
14 - LT BLU
18 - TAN
8917693
DIMMER SW COLUMN MTD
14-ORN - C
14 ORN - B
2984235
14-WHT
STOP LAMP SW
G.M.

Electromagnetic Components

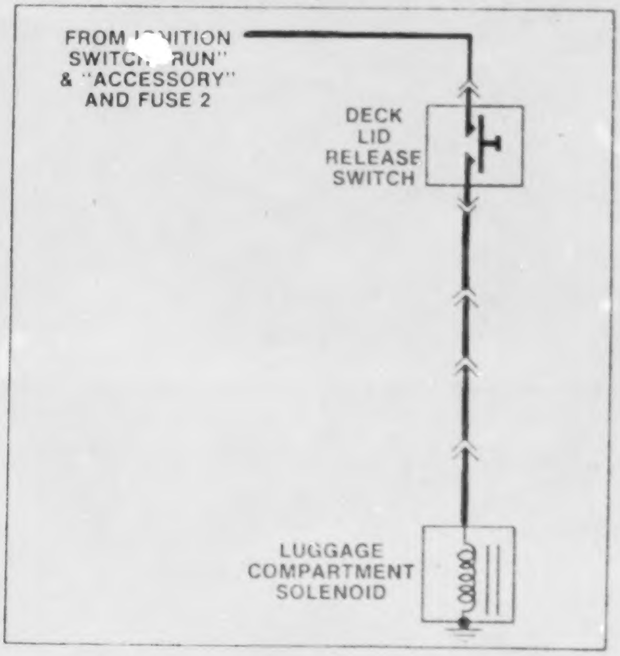
When an electrical current passes through a conductor a magnetic field is set up around the conductor. If the conductor is coiled, the magnetic field becomes concentrated and stronger. This electromagnetism is put to practical uses in such components as relays, buzzers, and solenoids.

The figure on the following page shows a circuit with typical relay and buzzer symbols (although other symbols are possible because of different construction of these parts). In this circuit the relay controls the buzzer. When the headlamp switch is on, as shown, circuit 14 carries power to the external lights and to the headlamp-on warning relay coil. When the relay coil is closed, the relay contacts provide a path to ground for the key reminder buzzer. The buzzer does not sound, however, until its coil is also energized, as it is whenever the courtesy lamp switch is closed. Thus, two conditions are necessary to operate the buzzer: the door must be open to close the courtesy lamp switch and provide power to the buzzer coil, and the headlight switch must be on to energize the relay and provide a path to ground for the buzzer circuit.


FROM FUSED BATTERY FEED
S-1008
FROM DIRECT BATTERY FEED
HEAD LAMP SWITCH
TO COURTESY LIGHTS
TO EXTERNAL LIGHTING
TO IGNITION KEY WARNING SWITCH
KEY REMINDER BUZZER
COURTESY LAMP SWITCH
TO COURTESY LAMP AND GROUND
HEADLAMP ON WARNING RELAY

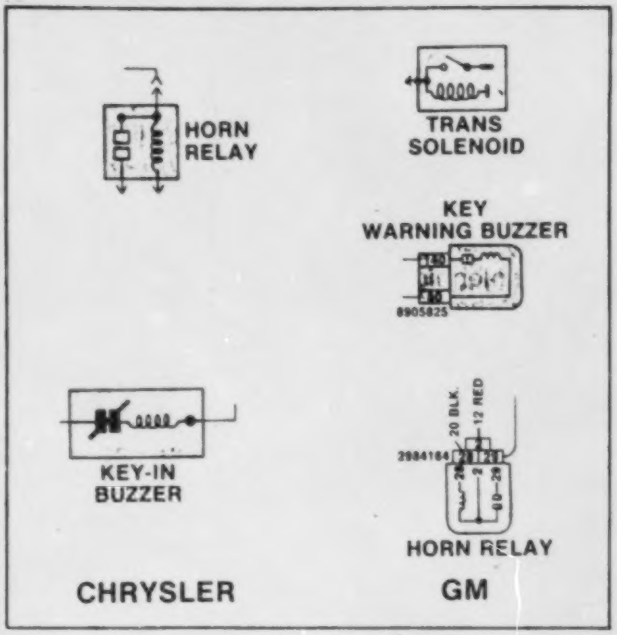
RELAY CONTROLLING BUZZER

The figure below shows the circuit and symbol for the solenoid in the luggage compartment latch mechanism.


FROM IGNITION SWITCH "RUN" & "ACCESSORY" AND FUSE 2
DECK LID RELEASE SWITCH
LUGGAGE COMPARTMENT SOLENOID

Related Information

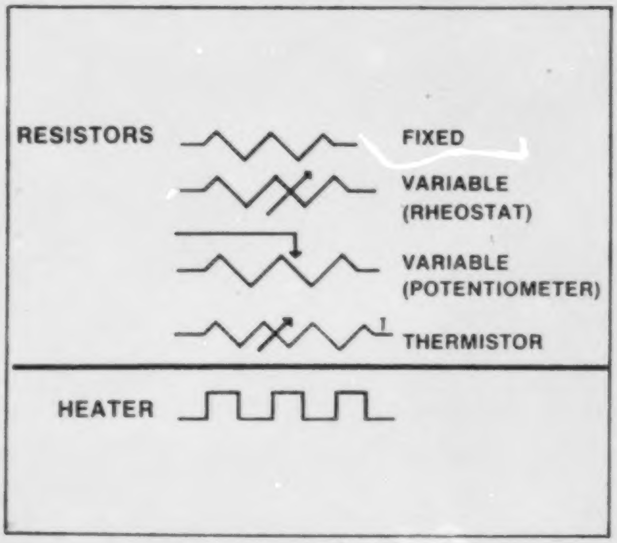
The figure below shows some typical Chrysler and GM electromechanical symbols.


HORN RELAY
TRANS SOLENOID
KEY WARNING BUZZER
8905825
KEY-IN BUZZER
20 BLK.
12 RED
2984164
HORN RELAY
CHRYSLER
GM

CHRYSLER AND GM RELAY, BUZZER, SOLENOID SYMBOLS

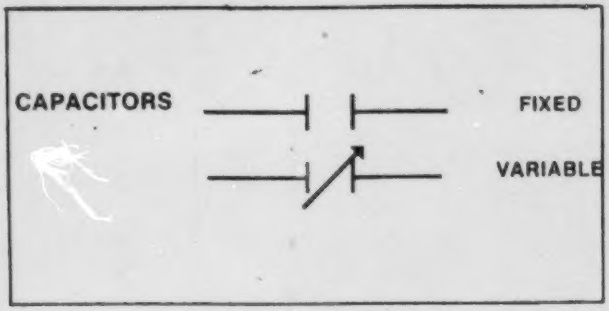
Resistors

Resistors are used to limit voltage in areas where full voltage is not required. Resistors may be of several types. The symbols for these types are shown below. These symbols are standard throughout the industry.


RESISTORS
FIXED
VARIABLE (RHEOSTAT)
VARIABLE (POTENTIOMETER)
THERMISTOR
HEATER

RESISTOR SYMBOLS

Capacitors (also called "condensers" store electrical energy temporarily. The figure below shows the symbols for fixed and variable capacitors.



CAPACITOR SYMBOLS

Capacitors are essentially open; that is, there is a space (dielectric) between the two capacitor plates. This space prevents the flow of current. However, the hot side of the capacitor will "charge" (store electrical energy).

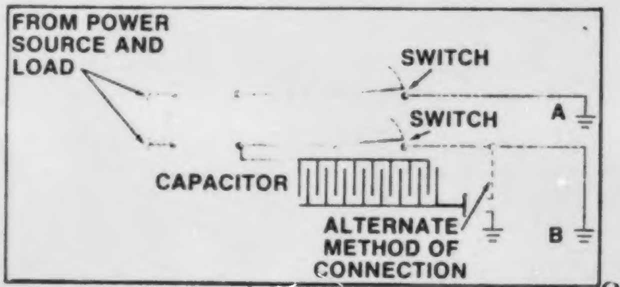
Let's say that the circuit is operating at 6 volts and there is a sudden voltage surge to 12 volts. Due to the increased voltage, current will flow into the capacitor until it is charged up to the 12 volt level. This changes the sudden surge of voltage into a gradual increase.

If the surge lasts only for an instant and the voltage then drops back to 6 volts, the capacitor will then feed current back into the circuit until capacitor voltage again matches circuit voltage.

Because this capacitor charging cycle occupies a definite length of time (dependent on voltage differential and capacitor storage capability) capacitors are sometimes used as a time delay control for certain voltage-sensitive components.

When subjected to alternating voltage or pulsating DC voltage, current will flow into and back out of the capacitor. At a given peak voltage pulse, the amount of current which will flow will be proportional to the frequency of the pulsations. This characteristic is utilized in tachometer circuits.

Capacitors may also be drawn as shown in the following figure. In a circuit such as shown in A, when the switch is opened, the sudden stoppage of current causes a momentary voltage surge on the hot side of the switch. This surge can cause an arc (spark) across the switch contacts. To prevent arcing, a capacitor may be installed as shown in B, in parallel with the switch. The capacitor then absorbs and stores the electrical surge. It discharges the stored voltage when the switch is closed.



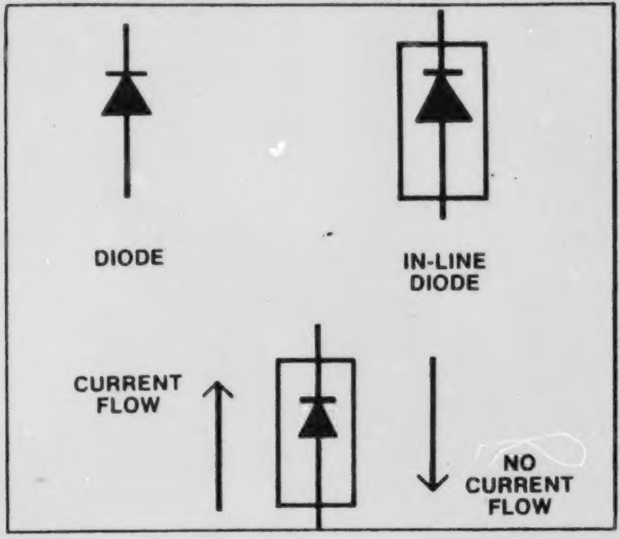
CAPACITOR USED TO STORE VOLTAGE SURGE

To summarize, capacitors can be used:

1. To smooth out voltage surges in a circuit.
2. To delay application of voltage changes to voltage-sensitive switching circuits.
3. To meter the current flow caused by a pulsating voltage of varying frequency.

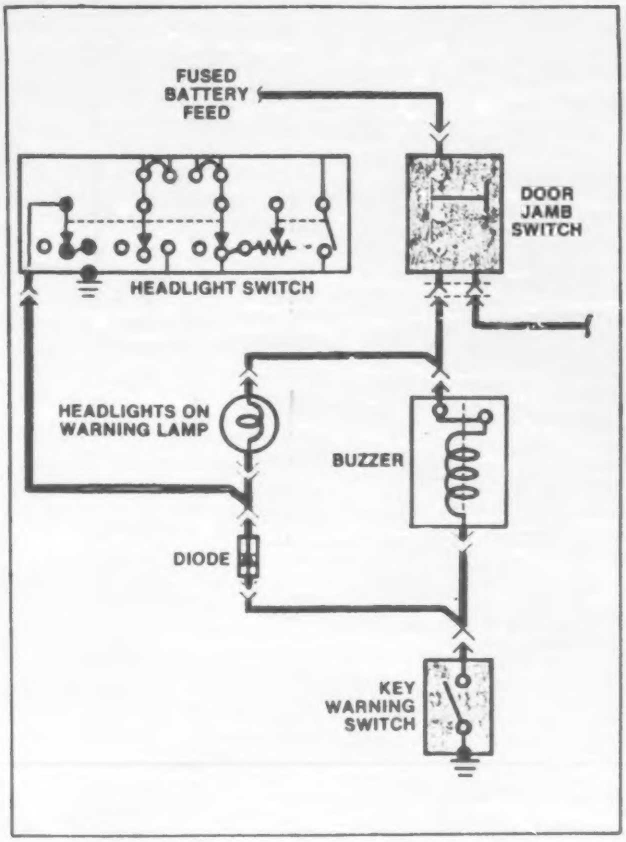
Diodes

Diodes are devices which pass current in one direction but block it in the opposite direction. The diode symbols are shown below.



DIODE SYMBOLS

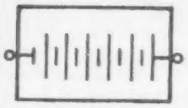
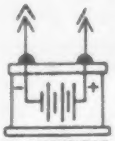
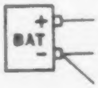
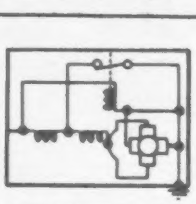
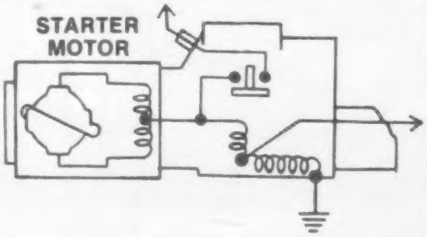
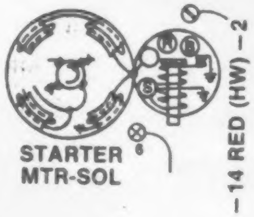
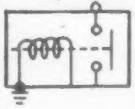
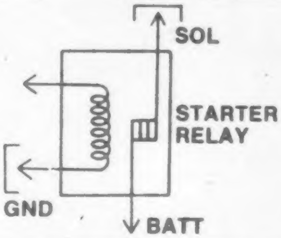
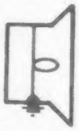
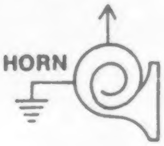
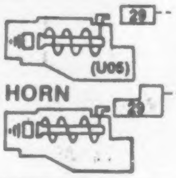
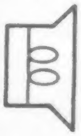
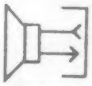
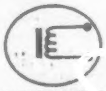
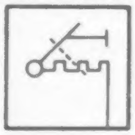
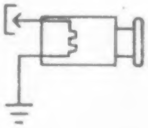
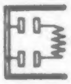
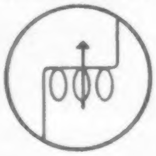
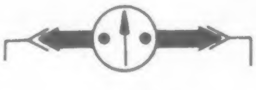
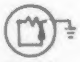
Current can pass in the direction the arrow points, but not in the opposite direction. The next figure presents an example of how a diode is used. This circuit is designed so that the warning light and buzzer come on whenever the driver's door is opened while the headlight switch is on. It is further designed so that only the buzzer comes on whenever the driver's door is opened while the key is in the ignition. As shown, the warning lamp can only be grounded through the far-left segment of the headlamp switch. The position of the diode prevents the lamp's grounding through a closed key warning switch. The position of the diode also allows the buzzer to be grounded through the headlight switch, even though the key warning switch is open. Diode and capacitor symbols are standard throughout industry.

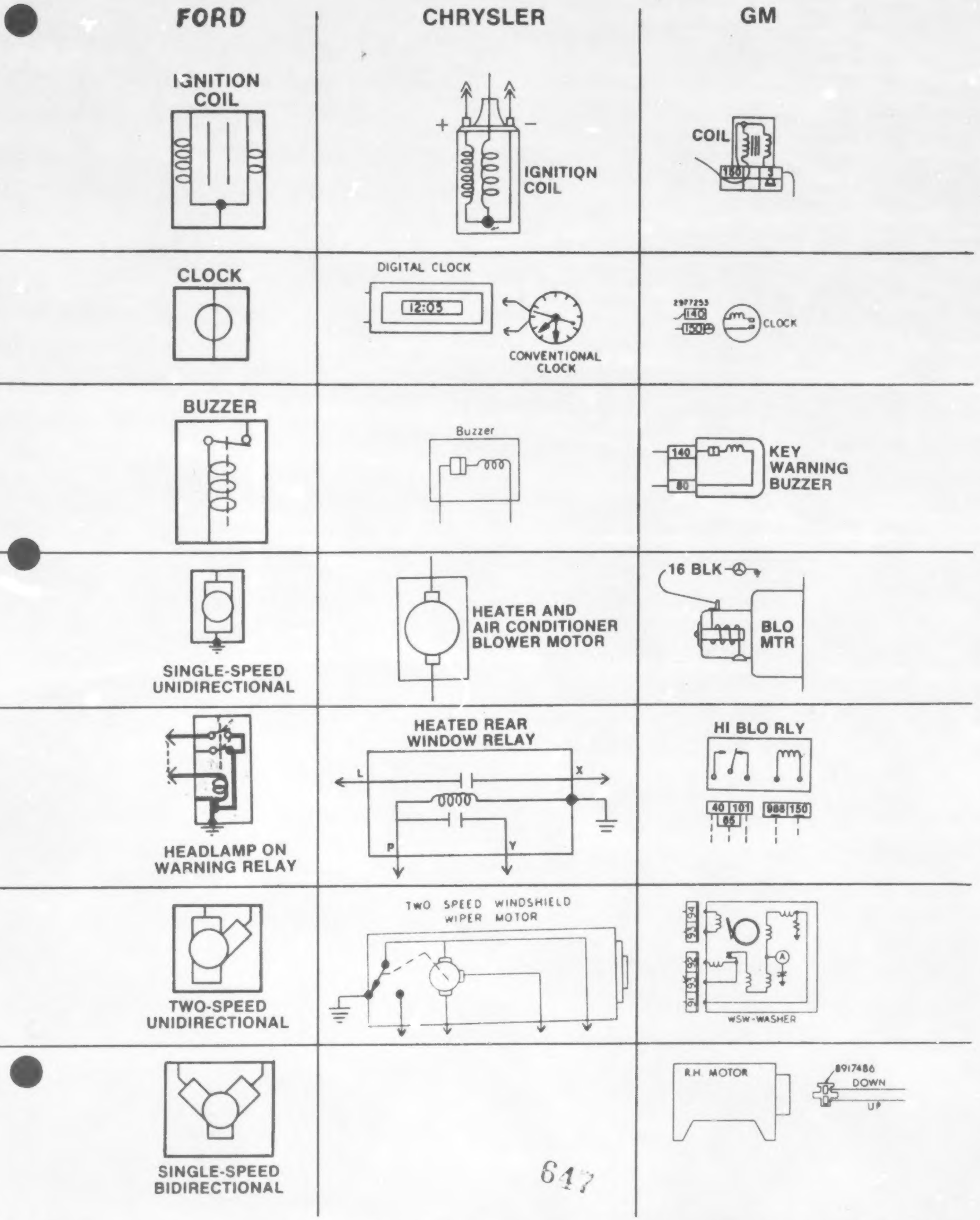

FUSED BATTERY FEED
DOOR JAMB SWITCH
HEADLIGHT SWITCH
HEADLIGHTS ON WARNING LAMP
BUZZER
DIODE
KEY WARNING SWITCH

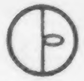
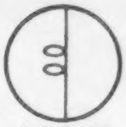
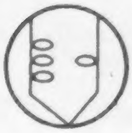
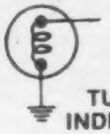
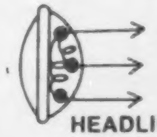
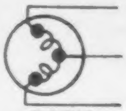
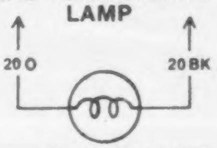
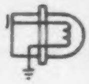
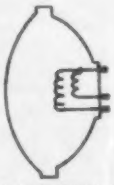
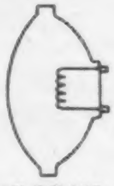
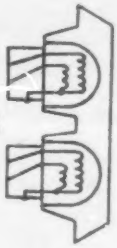
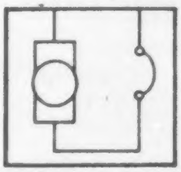
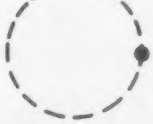
TYPICAL CIRCUIT WITH DIODE

Miscellaneous Symbols

The following pages show several other miscellaneous symbols with a comparison between Ford, Chrysler, and GM applications.

FORD	CHRYSLER	GM
12-VOLT BATTERY 	 BATTERY	
 STARTER MOTOR (TYPICAL) FOUR-POLE UNIDIRECTIONAL	STARTER MOTOR 	 STARTER MTR-SOL —14 RED (HW) —2
STARTER MOTOR RELAY 	 SOL STARTER RELAY GND BATT	
HORN 	HORN 	 HORN
SPEAKER 	 SPEAKER	 SPEAKE
CIGAR LIGHTER 	 CIGARETTE LIGHTER	 LIGHTER
METER (GAUGE) 	 AMMETER	 FUEL METER


FORD
CHRYSLER
GM
IGNITION COIL
+
–
IGNITION COIL
COIL
150
3
CLOCK
DIGITAL CLOCK
12:05
CONVENTIONAL CLOCK
2977253
140
150
CLOCK
BUZZER
Buzzer
140
80
KEY WARNING BUZZER
16 BLK
HEATER AND AIR CONDITIONER BLOWER MOTOR
BLO MTR
SINGLE-SPEED UNIDIRECTIONAL
HEATED REAR WINDOW RELAY
L
X
P
Y
HI BLO RLY
40
101
65
988
150
HEADLAMP ON WARNING RELAY
TWO SPEED WINDSHIELD WIPER MOTOR
94
93
192
193
91
A
WSW-WASHER
TWO-SPEED UNIDIRECTIONAL
R.H. MOTOR
8917486
DOWN
UP
SINGLE-SPEED BIDIRECTIONAL

FORD	CHRYSLER	GM
BULBS  SMALL SINGLE FILAMENT • INDICATORS • SIDE MARKERS • LICENSE • COURTESY • ILLUMINATION  LARGE SINGLE FILAMENT • CORNERING • HIGH BEAM • BACKUP  DUAL FILAMENT • STOP, PARK, TURN SIGNAL • LOW BEAM • RUNNING	 TURN SIGNAL INDICATOR LAMP  HEADLIGHT  PARK AND TURN SIGNAL LAMP  AIR CONDITIONER OR HEATER CONTROL LAMP	 LICENSE LP  HI-LO BEAM  HI-BEAM  TAIL, STOP, DIR LP
MOTOR  SINGLE-SPEED UNIDIRECTIONAL OR BIDIRECTIONAL DEPENDING ON EXTERNAL CIRCUITRY WITH CIRCUIT BREAKER		
WIRE SHIELD 		

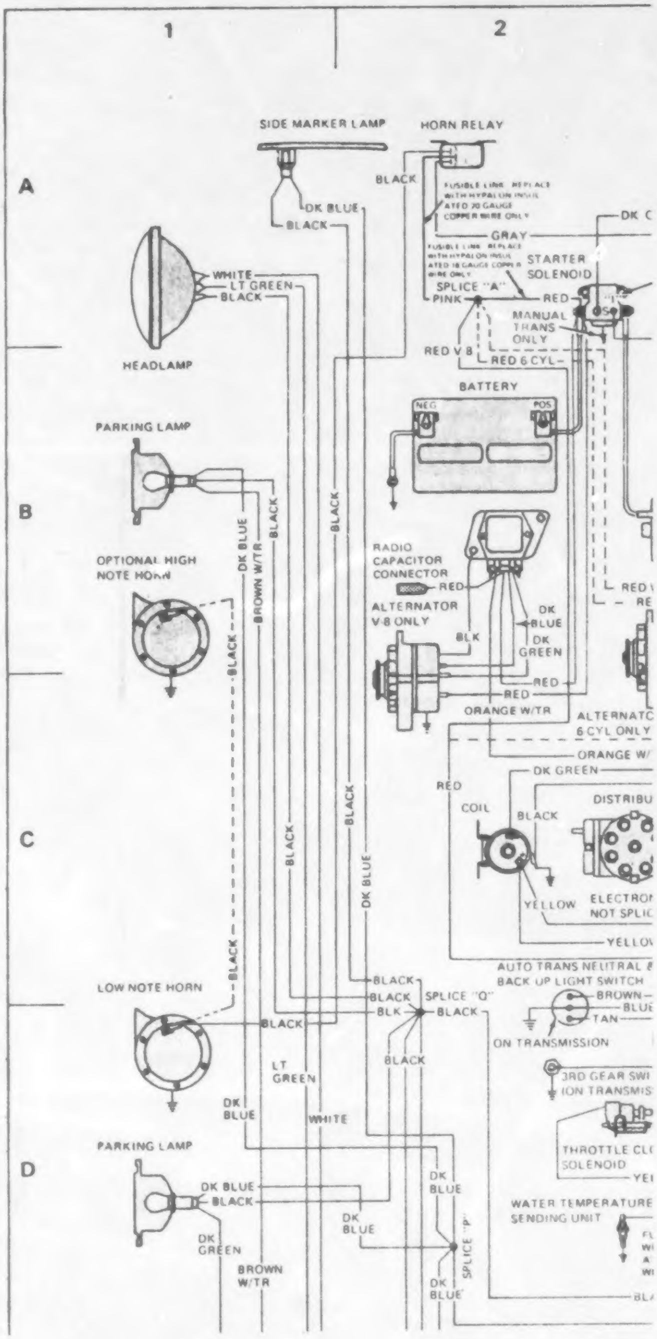
Special Diagram Provisions

Locating Components

On Ford, Chrysler, and American Motors wiring diagrams, an index and grid numbering system is used to locate components. The system works very much like a road map.

COMPONENT GRID LOCATOR HORNET AND GREMLIN

NOMENCLATURE	LOCATION
Alternator, 6 Cylinder (Delco)	C-2
Alternator, V-8 (Motorcraft)	B-2
Auto. Trans. Gear Selector Indicator Light	C-7
Auto. Trans. Neutral & Back-up Light Switch	C-2
Back-up Lamp, Left Rear (01 Only)	D-11
Back-up Lamp, Left Rear (40 Only)	E-11
Back-up Lamp, Right Rear (01 Only)	B-11
Back-up Lamp, Right Rear (40 Only)	A-11
Battery	B-2
Blower Motor	B-4
Blower Motor Resistor	A-6
Body Ground	C-11
Body Ground on Firewall	D-3 & E-3
Body Harness Connector	E-8
Brake Failure Warning Light Switch	A-4
Electronic Control Unit	A-3
Cigar Lighter	A-6
Coil	C-2
Courtesy Lamp, Left Side	D-9
Courtesy Lamp, Right Side	B-9
Dash Connector	D-4
Dimmer Switch	E-5
Directional Signal Flasher	D-8
Directional Signal Switch	C-8
Distributor	C-2
Dome Lamp	C-10
Door Switch, Left Front	D-9
Door Switch, Left Rear	D-9
Door Switch, Rear Hatch (Hatchback & Wagon)	C-10
Door Switch, Right Front	A-9
Door Switch, Right Rear	A-10
Electronic Sensor Wires	C-3
Fuse Panel	B-10 & E-5
Fusible Link Horn Relay	A-2
Fusible Link, Ignition Switch Circuit	B-8 & B-7
Fusible Link, Splice "L"	D-3
Fusible Link, Starter Main Wire Harness	A-2
Glove Box Lamp	A-9
Hazard Flasher	C-6
Headlamp, Left Side	E-1
Headlamp, Right Side	A-1
Headlamp Switch	D-7


1
2
A
B
C
D
SIDE MARKER LAMP
HORN RELAY
BLACK
DK BLUE
BLACK
GRAY
STARTER SOLENOID
WHITE
LT GREEN
BLACK
SPLICE "A"
PINK
RED
MANUAL TRANS ONLY
RED V 8
RED 6 CYL
HEADLAMP
BATTERY
NEG
POS
PARKING LAMP
DK BLUE
BROWN W/TR
BLACK
RADIO CAPACITOR CONNECTOR
OPTIONAL HIGH NOTE HORN
ALTERNATOR V-8 ONLY
BLK
DK BLUE
DK GREEN
RED
ORANGE W/TR
ALTERNATOR 6 CYL ONLY
DK GREEN
COIL
DISTRIBU
YELLOW
ELECTRON NOT SPLIC
DK BLUE
AUTO TRANS NEUTRAL & BACK UP LIGHT SWITCH
BROWN
TAN
SPLICE "Q"
ON TRANSMISSION
LOW NOTE HORN
LT GREEN
WHITE
3RD GEAR SWI ION TRANSMIS
THROTTLE CL SOLENOID
PARKING LAMP
DK GREEN
BROWN W/TR
WATER TEMPERATURE SENDING UNIT
SPLICE "P"

Locating "Hot" wires

Ford's wiring doagrams include a provision for circuit types through wire line identification.

Direct battery feed wires connect components which are fed power directly from the battery, such as the headlamp switch. This type wire appears as a heavy, solid line.

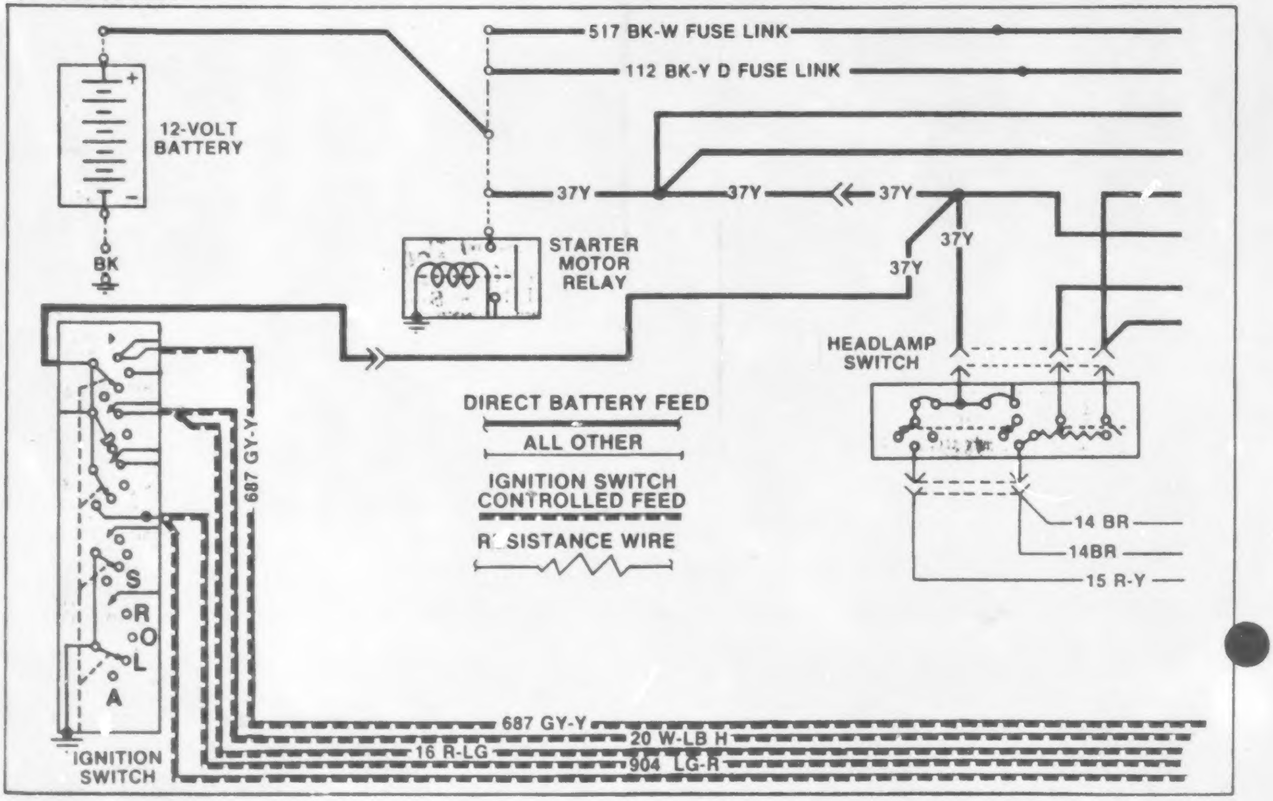
Ignition switch controlled feed wires connect components which receive power through the ignition switch, such as the radio. This type wire appears as a light line with a dashed overlay.

Resistance wires drop voltage to feed circuits where full power is not required. Resistance wires may be in direct battery fed or ignition switch fed circuits. Resistance wire appears as a wire with a resistor symbol in it.

Other wires include the wires powered indirectly by the battery through a switch, fuse, etc. This type wire appears as a solid light line.

Fuse link wires are provided for circuit protedtion in some circuits. This type wire appears as a solid line with a circuit identificaiton and the words "FUSE LINK" in the line (see illustration below)

NOTE:
Neither GM nor Chrysler uses different types of lines to represent different types of circuits.


517 BK-W FUSE LINK
112 BK-Y D FUSE LINK
+
12-VOLT BATTERY
−
BK
37Y
37Y
37Y
37Y
37Y
STARTER MOTOR RELAY
HEADLAMP SWITCH
DIRECT BATTERY FEED
ALL OTHER
IGNITION SWITCH CONTROLLED FEED
RESISTANCE WIRE
687 GY-Y
14 BR
14BR
15 R-Y
S
R
O
L
A
IGNITION SWITCH
687 GY-Y
20 W-LB H
16 R-LG
904 LG-R

TYPICAL POWER DISTRIBUTION DIAGRAM, SHOWING DIFFERENT CIRCUIT TYPES

TRACING ELECTRICAL CIRCUITS

Tracing electrical circuits in a wiring diagram and relating them to the automobile can be as easy or as difficult as you make it. It becomes easy when you have a planned approach and follow it. Here are some tips that should help you unwind a circuit from most wiring diagrams:

1. You're usually interested in just one circuit and not the whole wiring diagram. Don't let all those lines and symbols frighten you. Locate the circuit load component you're interested in, concentrate on it, and follow it back to its source of power.

2. Fundamentally, all electrical wiring diagrams use a common or standard set of electrical symbols. Learn these basic symbols.

3. The diagram wiring usually has a color and circuit code system that makes it easier to follow and identify an individual circuit not only in the wiring diagram but also on the vehicle. With a little effort, any of the coding systems can easily be self-taught in a few minutes. In some cases, the wires are shown in their actual color.

4. If a diagram location index is provided for locating circuit components, be sure to use it. Locating circuit components in a wiring diagram not familiar to you can become a difficult task.

5. Get acquainted with the car manufacturer's diagram layout. In most cases you will find that diagrams run in a continuous, logical sequence. The diagram for the whole car may be printed on one large master sheet or it may involve several continuous pages. Sometimes the chassis wiring is covered on several separate diagrams. For example, one car manufacturer divides its chassis wiring into three separate diagrams:

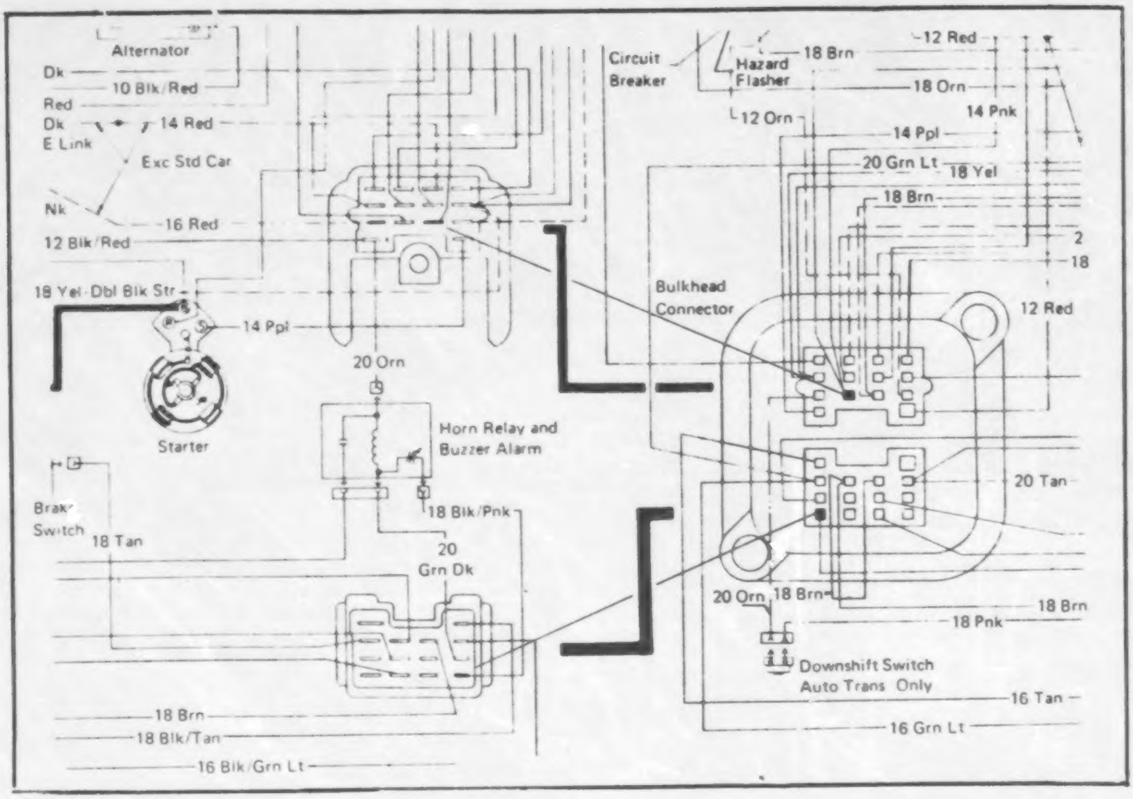
   (a) front end lighting and engine compartment
   (b) instrument panel
   (c) body and rear lighting

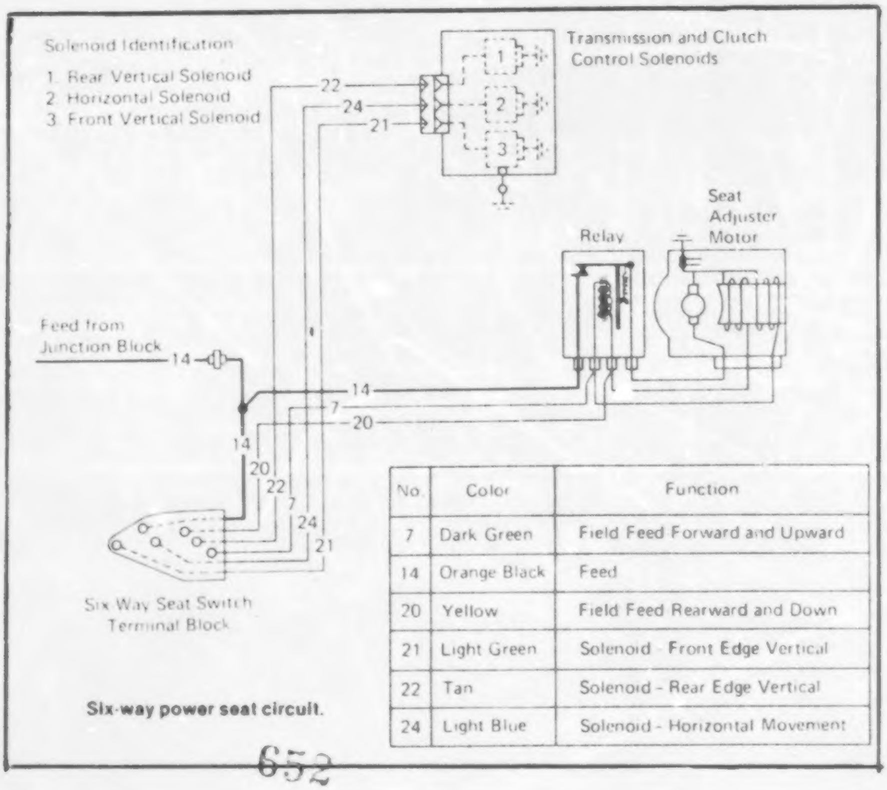
This means that when you're tracing a circuit it will usually involve transferring between diagrams.

6. You may find it difficult to trace a circuit through diagram multiple connectors that are not number- or letter-coded. The figure on the next page shows the connector ends of the engine harness and front-end lighting harness that must be matched to the bulkhead connectors. To correctly match the connector halves, simply place them side by side as two pages in a book and fold them together. Note how the matched terminals are illustrated in the bulkhead connectors.

7. The individual power-accessory circuits such as windshield wipers, seats, windows, etc., are sometimes shown separately from the main chassis wiring diagram. It is not uncommon to find the accessory circuit wiring details in the car manufacturer's body service manual (see diagram at the bottom on the next page).

Information Sheet #3


Alternator
Dk
10 Blk/Red
Red
Dk
E Link
14 Red
Exc Std Car
Nk
16 Red
12 Blk/Red
18 Yel-Dbl Blk Str
14 Ppl
Starter
20 Orn
Horn Relay and
Buzzer Alarm
Brake
Switch
18 Tan
18 Blk/Pnk
20
Grn Dk
18 Brn
18 Blk/Tan
16 Blk/Grn Lt
Circuit
Breaker
Hazard
Flasher
18 Brn
12 Red
18 Orn
12 Orn
14 Pnk
14 Ppl
20 Grn Lt
18 Yel
18 Brn
2
18
12 Red
Bulkhead
Connector
20 Tan
20 Orn
18 Brn
18 Brn
18 Pnk
Downshift Switch
Auto Trans Only
16 Tan
16 Grn Lt


Solenoid Identification
1. Rear Vertical Solenoid
2. Horizontal Solenoid
3. Front Vertical Solenoid
22
24
21
1
2
3
Transmission and Clutch
Control Solenoids
Seat
Adjuster
Motor
Relay
Feed from
Junction Block
14
14
7
20
14
20
22
7
24
21
Six Way Seat Switch
Terminal Block

No.	Color	Function
7	Dark Green	Field Feed Forward and Upward
14	Orange Black	Feed
20	Yellow	Field Feed Rearward and Down
21	Light Green	Solenoid - Front Edge Vertical
22	Tan	Solenoid - Rear Edge Vertical
24	Light Blue	Solenoid - Horizontal Movement

Six-way power seat circuit.

An Example Circuit Trace

For diagnosis purposes, a circuit may be traced from component to power source or from power source to component. When diagnosing for an open circuit, the former direction is often used.

In this exercise, we will be concerned with tracing a Dodge Dart right side backup light. The object is to follow the complete circuit from the light and its ground to the ultimate power source, the battery. Along the way, we will be noting wire color, slices, connectors, switches, and circuit protection devices. We will also take note and identify splice intersections, termed "common points," where other circuits join and derive their power from the circuit we are tracing. All of the steps and much of the information would be necessary if we were to actually diagnose, test, and repair the circuit.

The exercise will follow the attached wiring diagram from a 1976 Chrysler Service Manual. As you read the steps, follow along on the diagram to become familiar with its use. Other manufacturers wiring diagrams will vary in design with Ford Motor Companys diagrams being the closest. Many of the principles covered here can be readily transfered for use on any wiring diagram.

1. We can locate the component (right side backup light) in the index on page 8-231. Here we find backup lights listed under lamps. The right side lamp is located at grid 87-B on the diagram.

2. Proceding to the diagram itself, we locate the grid reference (87-B) and the right backup lamp on page 8-253.

3. The backup lamp is designated CB13. The CB indicates that it is a connector located in the body area. A chart on the back pages of the diagram (page 8-267) shows the bulb socket with its ground connection. It also tells you that the bulb is located above the rear bumper. Note that the ground wire is designated X2/18GY, and the feed wire is B2/18V.

4. Locating the code charts on page 8-228 and 8-229, we find that the "X" circuits indicate radio, cigar lighter, lamp grounds, clock, speed control, power antenna, deck lid and door locks. "18" tells us that the wire gauge size is 18, and "GY" indicates the wire insulation is gray. "B2/18V" for the live wire indicates that it is a backup light circuit wire of 18 gauge with a violet insulation color.

5. Back to page 8-253, (87-B) we can trace the ground circuit of the right backup light by following wire X2/18GY from CB13. Here we find our first splice point. Tracing the wires from the splice, we find that all rear lamps join at this point including the left backup lamp. One wire from this "common point" leads to a connector CB10.

6. Designation CB10 indicates that this is a connector located in the body area. Locating the designation number on page 8-267, we see that this is an eyelet connector attached in the deck lid area.

7. Back to page 8-253 (B7-B) we can trace the live side of the circuit. Following B2/18V we come to our second splice point. Here we find, when following B2/18V to the right, that the left backup lamp is in parallel. In diagnosis, if both backup lamps were not operating, we could assume that the problem would be to the left, or before, this "common point." If only one lamp were not operating, we would assume that the problem would be after this "common point" in the respective feed to the lamp or in its ground. (see Common Point Diagnosis, Competency F-9.)

8. Following B2/18V to the left of the splice point, we continue to the preceding page where we find a connector at grid 83-C. The connector is designated CB1 but is enclosed in a bracket which indicates an optional connection. Following B2/18V further we find respectfully a splice point and another optionally indicated connector also designated CB1.

9. Locating the body connector designation CB1 on page 8-266 we find that this is the main connector between the body wiring harness and the instrument harness. The brackets at the connector indicate that an optional tapping wire section can be added between the two normal connectors. This is verified by the trailer tow wire diagram shown. The connector CB1 is located at the left side of the cowl.

10. Returning to page 8-252 we can observe the relationship of the optional trailer tow harness to the rest of the system. From the "common point" splice, the trailer harness follows a path back to page 8-253. Here at 86-D, it meets an optionally designated connector CB22. Attached to this connector is a 7 way connector, CB23. Both of these connectors are pictured on page 8-268.

11. To continue our trace of the backup lamp circuit, we find that connector CB1 (grid 81-B on page 8-252) is directed to grid zone 62-C.

12. Grid 62-C is located on page 8-247. Here we find connector CB-1 with a grid designation below it. This verifies our original location so we know it is the correct connection. Note that our wire is now designated B2/18V/BK*. This indicates that a black tracer or strip has been added. This wire proceeds to the left where it meets connector CE1. (Note that it is located at grid 64-C.)

13. Connector CE1 is an engine compartment connector and its pictorial can be found on page 8-256. Here we see that this is the main bulkhead disconnect. Referring to the chart accompanying the pictorial, zone 64-C is listed in the far right column (instrument panel side). Following this line to the left we find the correct B2/18V/BK* circuit and its connector cavity location which is #7. If we were looking for a test point, we could locate the cavity in the connector by referring to its diagram. Continuing on the same line to the left we enter the engine compartment side of the connector where we find the same wire code. The next column to the left gives us a grid zone location where we can continue to trace the circuit. Here we find three zones designated by symbols. Zone 32-A is for 4 speed transmissions, zone 30-A is for 3 speed transmissions, and zone 29-A is for automatic transmissions. (This also complies with the grid references found below the connector CE1 on page 8-247). The bulkhead disconnect is located under the dash panel - left side below windshield wiper motor.

14. Our example vehicle has a 4 speed manual transmission, the grid zone 32-A is located on page 8-239.

15. On page 8-239 (32-A) we find the connector CE-1 and our B2/18V/BK* wire. Here the wire joins connector CE38. The male part of this connector includes a splice wire. As a result, it is designated as CE39. It is only used on 4 speed transmission equipped vehicles. Both of these connector designations can be found on page 8-260.

16. On page 8-260, we find the engine compartment connectors CE-38 and CE-39. Connector CE-39 includes a jumper wire for a reverse indicator light. As an additional circuit take off, this makes Ce-38/39 a "common point." The connector is located at the right rear of the engine.

17. Back on page 8-239, we can continue to follow our B2/18V/BK* wire. At the CE-39 connector, the jumper wire returns to an optional connection at CE1 (bracket indication). Wire B2/18V/BK* continues through connector CE38 to the backup lamp switch designated CE37.

18. Page 8-260 shows a pictorial view of the backup lamp switch connection. A view of an automatic transmission switch is also shown. Note that the wire leaving the upper part of the switch is designated B1/18W (18 gauge-black color). This indicates that it is still a backup lamp circuit wire of 18 gauge with white insulation color. The switch is located on the lower left side of the transmission.

19. Returning to page 8-239, we will follow wire B1/18W away from the switch. In doing this we discovered that the circuit again passes through connector CE38/39. The wire color location in the connector can be determined by consulting the connector pictorial on page 8-260. From this connector the B1/18W wire enters connector CE1 (the bulkhead disconnect). The grid zone is 32-E.

20. To continue our trace, we now need to return to page 8-256 and the bulkhead disconnect chart. At this point, we will be tracing both wires B1/18W and B2/18V/BK* (the reverse indicator circuit - grid zone 32-B.)

21. To find our circuits in the chart on page 8-256 we locate the last grid zones in the first column (engine compartment side). Zone 32-E enters cavity #8 retains its wire code designation, and exits to grid zone 64-C. Zone 32-B (reverse indicator) enters cavity #4, changes its wire code to B2/18W* (18 gauge - white with tracer), and exits to grid zone 47-D.

22. If the circuit were being traces to locate a short, it would be wise at this point to locate the indicator light circuit. Grid Zone 47-D is found on page 8-243. Here we can follow wire B2W* to the reverse gear indicator lamp designated C140. The CI designation indicates that this is an instrument panel compartment connector. It can be found on page 8-265. The lamp socket has a direct ground and is located to the left of the ashtray.

23. Continuing on with our original backup lamp circuit, we locate grid zone 64-C on page 8-247. Here we locate connector CE1 and Wire B1/18W*. Following the wire to the left we encounter a splice ("common point"). Tracing each wire in turn, we find that X12/18R provides power to the radio (71-E), D1/18BK leads to fuse #2 in the fuse block (59-D), C1/19LGN powers the air conditioning compressor clutch switch (79-C), and D1/18BK powers the turn signal flasher (61-C).

24. If we were tracing the backup lamp circuit for diagnosis, the fact that any of the above components operated would indicate that we had power to this common point. We would know this without actually testing the circuit at the splice. It is apparent that the lower D1/18BK wire supplies power to this "common point" from fuse #2 in the fust block located on the preceding page (59-D).

25. Examining the fuse block diagram on page 8-246 (59-D) we note the designation of a buss bar on the upper part of the diagram. Wire Q2/14BK (14 gauge-black color) leads to this buss bar. Note that the wire size increases to handle more load. The fuse panel is designated C124.

26. On page 8-263 we find the fuse Block C124. Locating fuse #2, we note that wire DJ/18BK leaves the fuse, and wire Q2/14BK connects to the buss bar marked ACC (accessory). Wire Q2/14BK also supplies power to fuse #3, and #4 along with all their respective circuits. The fuse block is located under the instrument panel on the left side lower reinforcement. Fuse sizes are indicated on a separate page (no. 8-217) attached to the end of this diagram. Fuse #2 is 20 amps.

27. Returning again to page 8-246 (59-D), we can continue to trace our circuit back to the battery. Following wire Q2/14BK to the bottom of the page we find a splice. Tracing each of these wires in turn we find that wire V1/14P (14 gauge -pink) leads to the windshield wiper switch (at 74-D) where it enters a circuit breaker. Wire Q2/12BK (12 gauge - black) travels to preceding pages where it enters the ignition switch at connector CI1 (42-B).

28. Instrument Panel Compartment connector symbol CI1 on page 8-262 shows the connection for wire Q2/12BK. This is separate from the multi-connector due to the larger wire sizes being used. The connector is located on the right side of the steering column.

29. A closer examination of the ignition switch on page 8-242 shows that wire Q2/12K (now designated 12BK) enters the switch and makes contact to a bar connector for both the run and accessory key positions. This tells us that the backup lamps will only operate when the key is turned. The switch wiper is connected to a bar with only one power feed terminal. Wire 12R (red) is connected to this terminal. Following 12R from the switch, we find that it also connects at CI1. From there it becomes J1/12R and leads to connector CE1 (bulkhead disconnect). The grid zone is 41-E.

30. The bulkhead disconnect chart on page 8-256 lists zone grid 41-E in the right column (instrument panel side of the connector). Here we can find wire J1/12R where it enters cavity #25. The wire exits as the same color to grid zone 24-C.

31. Grid zone 24-C is found on page 8-237. Here we can follow wire J1/12R to a splice. This is a single wire splice and joins wire J1/12R to wire J1/118GY* (18 gauge - gray with tracer). The J1/18GY wire is marked as a fusible link and designated CE28.

32. Locating the CE28 diagram in the engine compartment connector section, page 8-259, we find that the J1/18GY* fusible link is one of several. All are spliced to wire R6/10BK (10 gauge - black). The fusible links are located on the left of the dash panel (firewall).

33. Returning to page 8-237 (24-C) we can locate the splice point with wire R6/10BK by following the fusible link. The branching circuits at this "common point" besides wire R6/10BK, include wire R6/14R*, spliced to wire R6/10BK from the alternator, and wire R6/16DBL spliced to wire R6/12BK, power feed to headlight switch (47-B) and direct battery power to fuse block (58-B). Optional circuits may connect, these are labeled and indicated by dashed lines.

34. Following wire R6/10BK from the splice, we encounter another splice with wire R16/20BK*. Tracing this wire, we find it connects to the ammeter (55-B). Wire A11/20R* returns from the ammeter and enters a splice further along on wire R6/10BK. The short segment between the two ammeter splices provides a shunt for ammeter calibration.(Shortening or lengthening this wire may cause the ammeter to read inaccurately). Also entering into this second splice are two wires designated A1/10R. Tracing these wires in turn, we find that one leads to connector CE35 at the starter relay (28-D). The other wire A1/10R travels to the preceding page where it enters connector CE29. Details for connector CE35 are found on page 8-260. The CE29 connector is found on page 8-259.

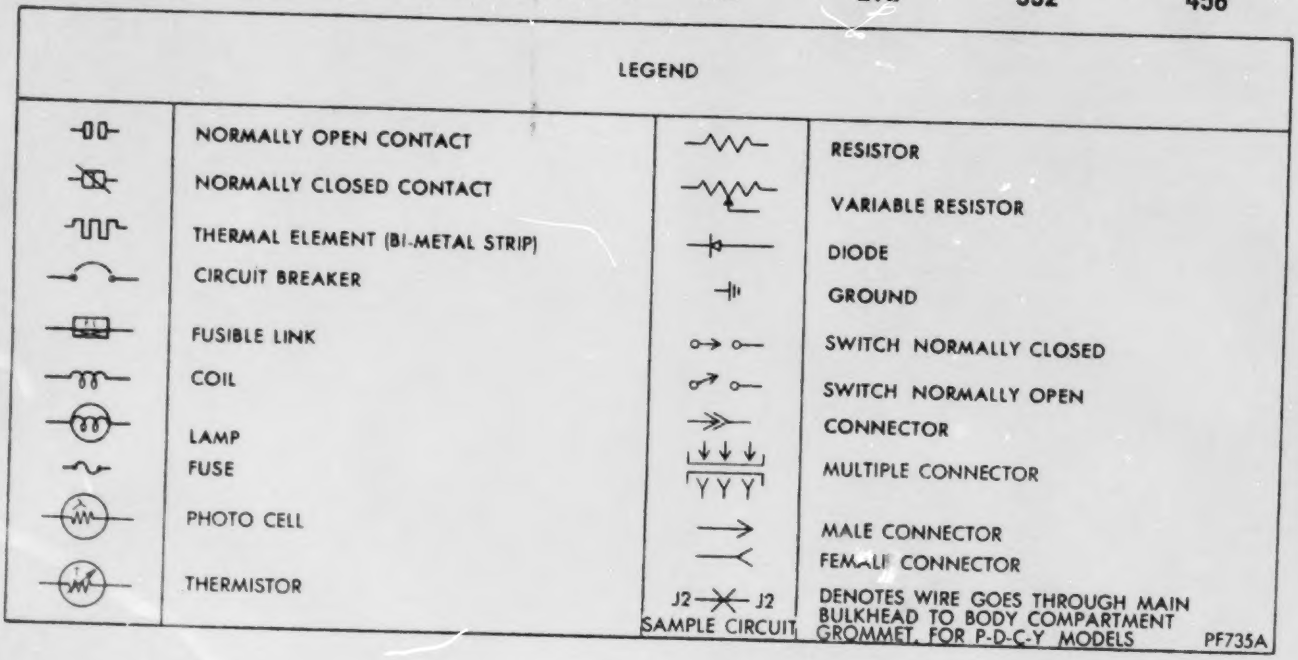
35. On page 8-259, we see that engine compartment connector CE29 is an in line battery connector for a single wire. It is located at the center of the left side shield (inner fender panel). Note that the connector joins wire A1/10R to wire A1/8R.

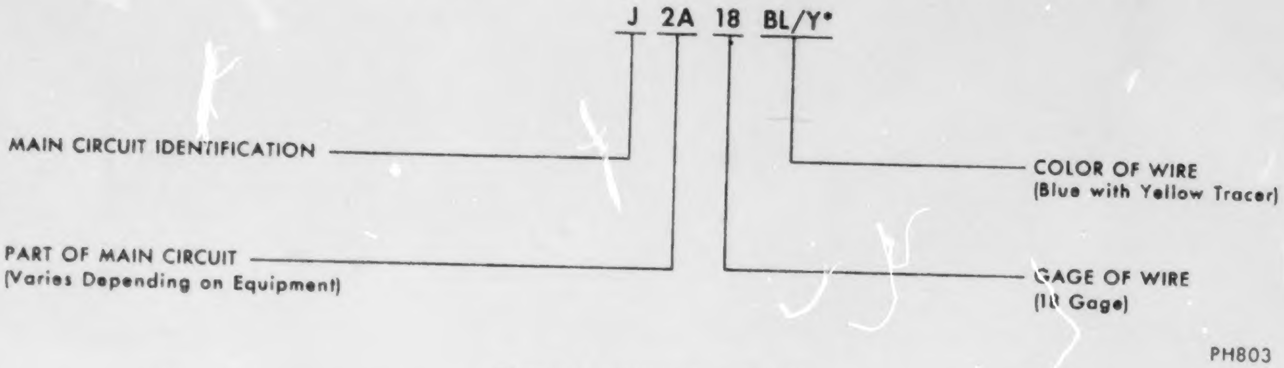
36. Returning to page 8-236, we find that wire A1/8R leads from connector CE29 and joins at connector CE30 - the battery cable clamp and the battery.

37. On page 8-259 the battery connectors CE30 are shown. Note that connection also provides a common point for wire A1/6R, to the starter motor and A3/14P, a single feed to the hazard warning flasher. The CE30 ground connector provides a common point for wires A2/6BK, engine ground, and A2/10BK, headlight and general body ground. These connectors and the battery are located at the front of the left side shield (inner fender panel).

CONTENTS

	V-L Page	R-W-X-S Page	P-D-C Page	H-N Page
ALPHABETICAL INDEX	230	269	348	454
CIRCUIT IDENTIFICATION CODES	228	228	228	228
COLOR CODE CHART	229	229	229	229
CONNECTOR CHARTS				
CB—BODY	266	340	442	509
CE—ENGINE COMPARTMENT	256	326	426	496
CI—INSTRUMENT PANEL	262	333	432	501
DISTRIBUTOR SECONDARY WIRING	230	230	230	230
ENGINE IDENTIFICATION CODES	229	229	229	229
LEGEND	228	228	228	228
WIRING DIAGRAMS	232	272	352	456


LEGEND
NORMALLY OPEN CONTACT
NORMALLY CLOSED CONTACT
THERMAL ELEMENT (BI-METAL STRIP)
CIRCUIT BREAKER
FUSIBLE LINK
COIL
LAMP
FUSE
PHOTO CELL
THERMISTOR
RESISTOR
VARIABLE RESISTOR
DIODE
GROUND
SWITCH NORMALLY CLOSED
SWITCH NORMALLY OPEN
CONNECTOR
MULTIPLE CONNECTOR
MALE CONNECTOR
FEMALE CONNECTOR
J2 J2
SAMPLE CIRCUIT
DENOTES WIRE GOES THROUGH MAIN BULKHEAD TO BODY COMPARTMENT GROMMET, FOR P-D-C-Y MODELS
PF735A


J 2A 18 BL/Y*
MAIN CIRCUIT IDENTIFICATION
PART OF MAIN CIRCUIT (Varies Depending on Equipment)
COLOR OF WIRE (Blue with Yellow Tracer)
GAGE OF WIRE (18 Gage)
PH803

Circuit Identification Codes

MAIN CIRCUIT IDENTIFICATION CODES

1	Battery Circuit to Ammeter.
A2	Battery Circuit to Ammeter.
B	Back Up Lamp Circuit.
C	Air Conditioning and Heater Circuits
D	Emergency, Stop Lamp and Turn Signal Circuits.
E	Instrument Panel Cluster, Switches and Illumination Circuits.
F	Radio Speakers and Power Seat Circuits.
G	Gauges and Warning Lamp Circuits.
H	Horn Circuit.
J	Ignition System Run Circuit.
J1	Ignition Switch Feed Circuit.
J3	Ignition Switch Start Circuit.
L	Lighting Circuit (Exterior Lights).
M	Lighting Circuit (Interior Lights).
P	Brake Checking Circuit.
Q2	Accessory Buss Bar Feed (Fuse Block).
Q3	Battery Buss Bar Feed (Feed).
R3	Alternator Circuit to Electronic Voltage Regulator (Field).
R6	Alternator Circuit to Ammeter (Feed).
S	Starter Motor and Starter Relay Circuit.
T	Trunk Lamp Circuit.
V	Windshield Wiper and Washer Circuit.
W	Power Window Circuit.
X	Radio, Cigar Lighter, Lamp Grounds, Clock, Speed Control, Power Antenna, Deck Lid and Door Locks.

ENGINE IDENTIFICATION CODES*

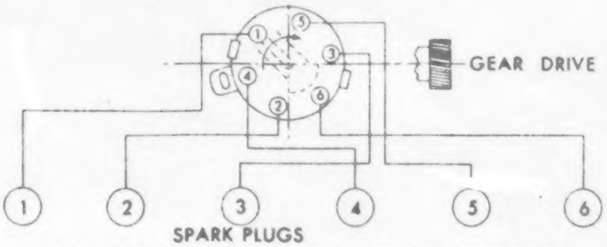
E24	225—1 bbl.	(Standard)
E25	225—1 bbl.	(Heavy Duty Fleet)
E44	318—2 bbl.	
E56	360—4 bbl.	(Standard)
E57	360—2 bbl.	
E58	360—4 bbl.	(High Performance)
E63	400—2 bbl.	
E64	400—4 bbl.	(Standard)
E68	400—4 bbl.	(High Performance)
E85	440—4 bbl.	(Standard)
E86	440—4 bbl.	(High Performance)

***For Reference In Wiring Diagrams Only.**

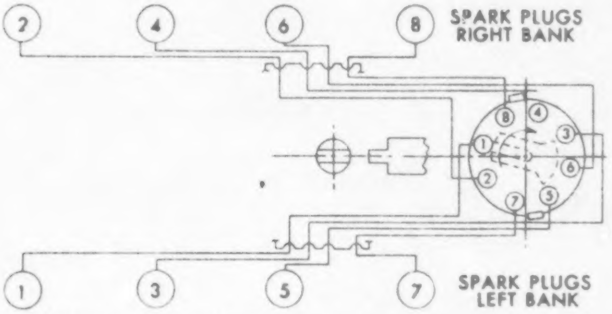
COLOR CODE

BK	BLACK	P	PINK
BR	BROWN	R	RED
DBL	DARK BLUE	T	TAN
DGN	DARK GREEN	V	VIOLET
GY	GRAY	W	WHITE
LBL	LIGHT BLUE	Y	YELLOW
LGN	LIGHT GREEN	*	WITH TRACER
O	ORANGE		

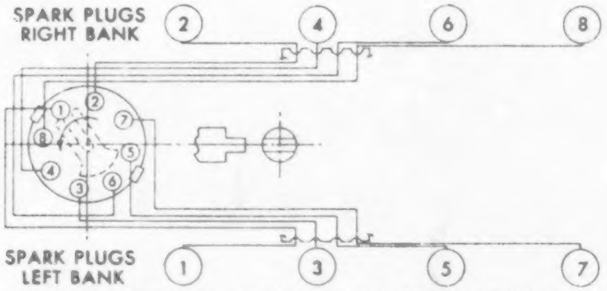
PK456


GEAR DRIVE
1
2
3
4
5
6

SPARK PLUGS
SIX CYLINDER DISTRIBUTOR-CLOCKWISE ROTATION
FOR 225 CUBIC INCH ENGINES
FIRING ORDER-1-5-3-6-2-4


2
4
6
8
SPARK PLUGS RIGHT BANK
1
3
5
7
SPARK PLUGS LEFT BANK

EIGHT CYLINDER DISTRIBUTOR-CLOCKWISE ROTATION
FOR 318 AND 360 CUBIC INCH ENGINES
FIRING ORDER-1-8-4-3-6-5-7-2


SPARK PLUGS RIGHT BANK
2
4
6
8
SPARK PLUGS LEFT BANK
1
3
5
7

EIGHT CYLINDER DISTRIBUTOR-COUNTER-CLOCKWISE ROTATION
FOR 400 AND 440 CUBIC INCH ENGINES
FIRING ORDER-1-8-4-3-6-5-7-2

PD541B

Distributor Secondary Wiring

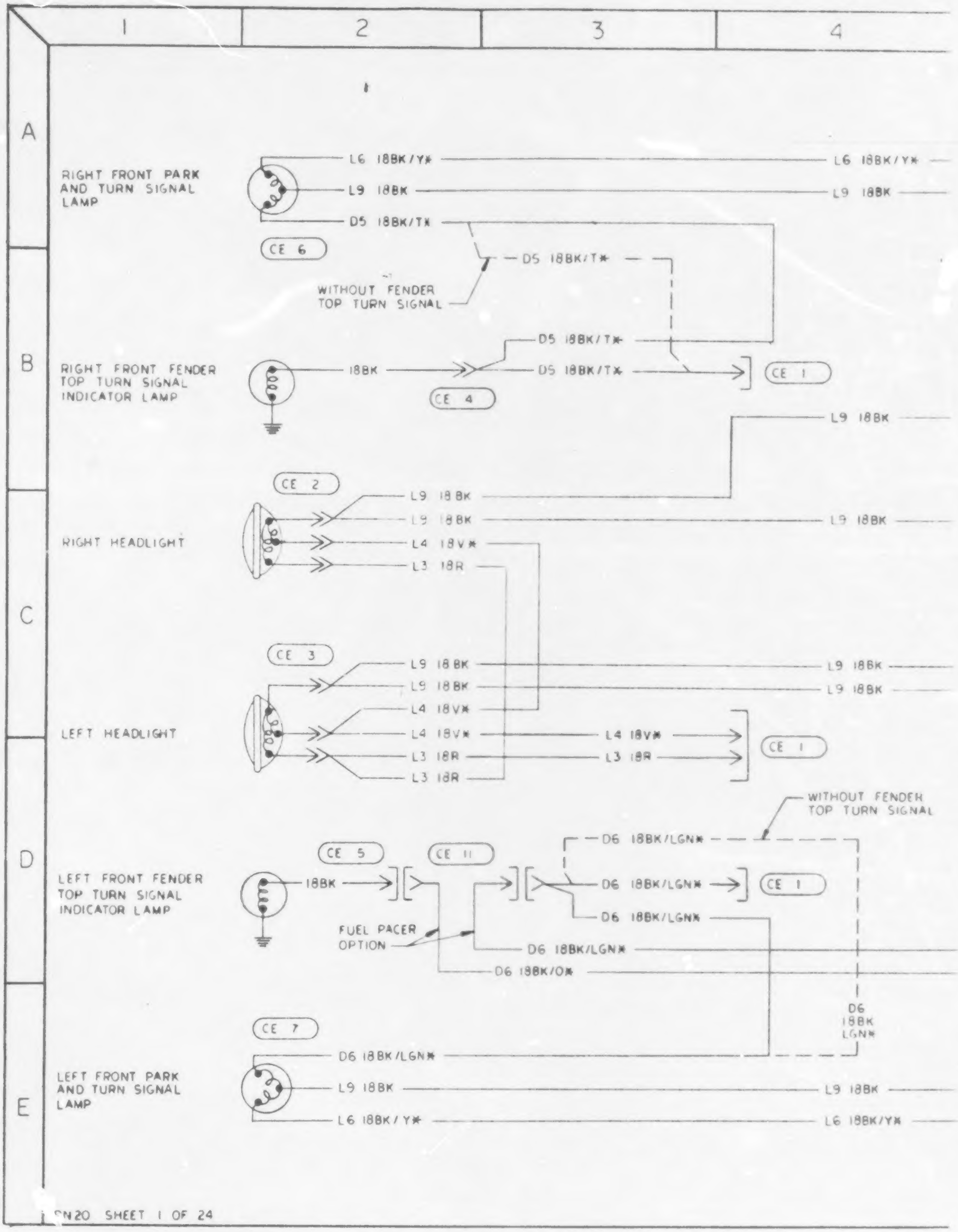
V-L MODELS
ALPHABETICAL INDEX

NAME	ZONE LOCATION
Air Conditioning Resistor Block	80D
Air Conditioning Compressor Clutch	33B
Alternator	17B
Battery	19D
Ballast Resistor	14A
Choke Control	12E
Choke Heater	11E
Cigarette Lighter	67C
Distributor	15C
Electronic Ignition Control	14B
Exhaust Gas Recirculation Timer	12A
Exhaust Gas Recirculation Vacuum Solenoid	10C, 10D

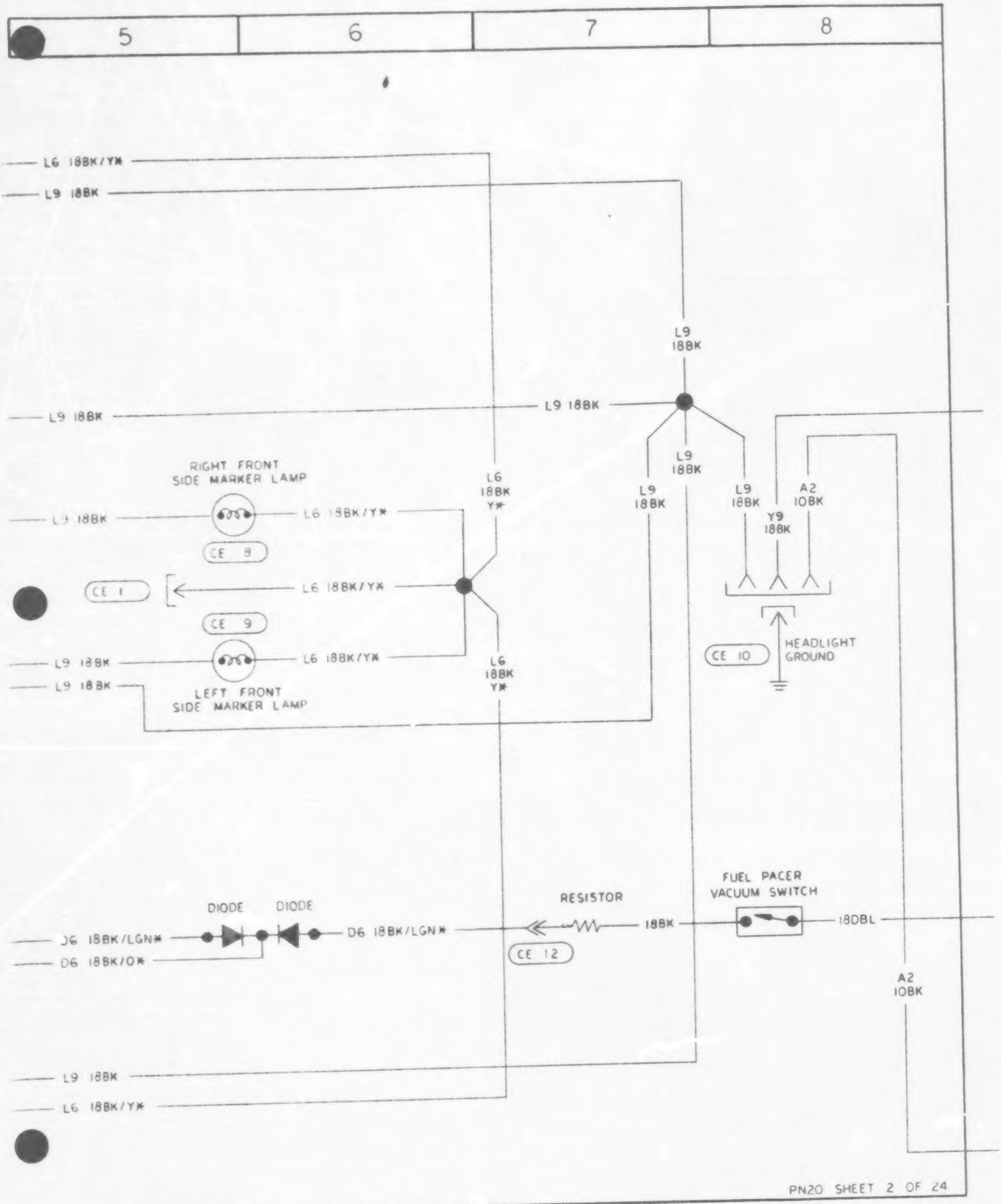
ALPHABETICAL INDEX (Cont'd)

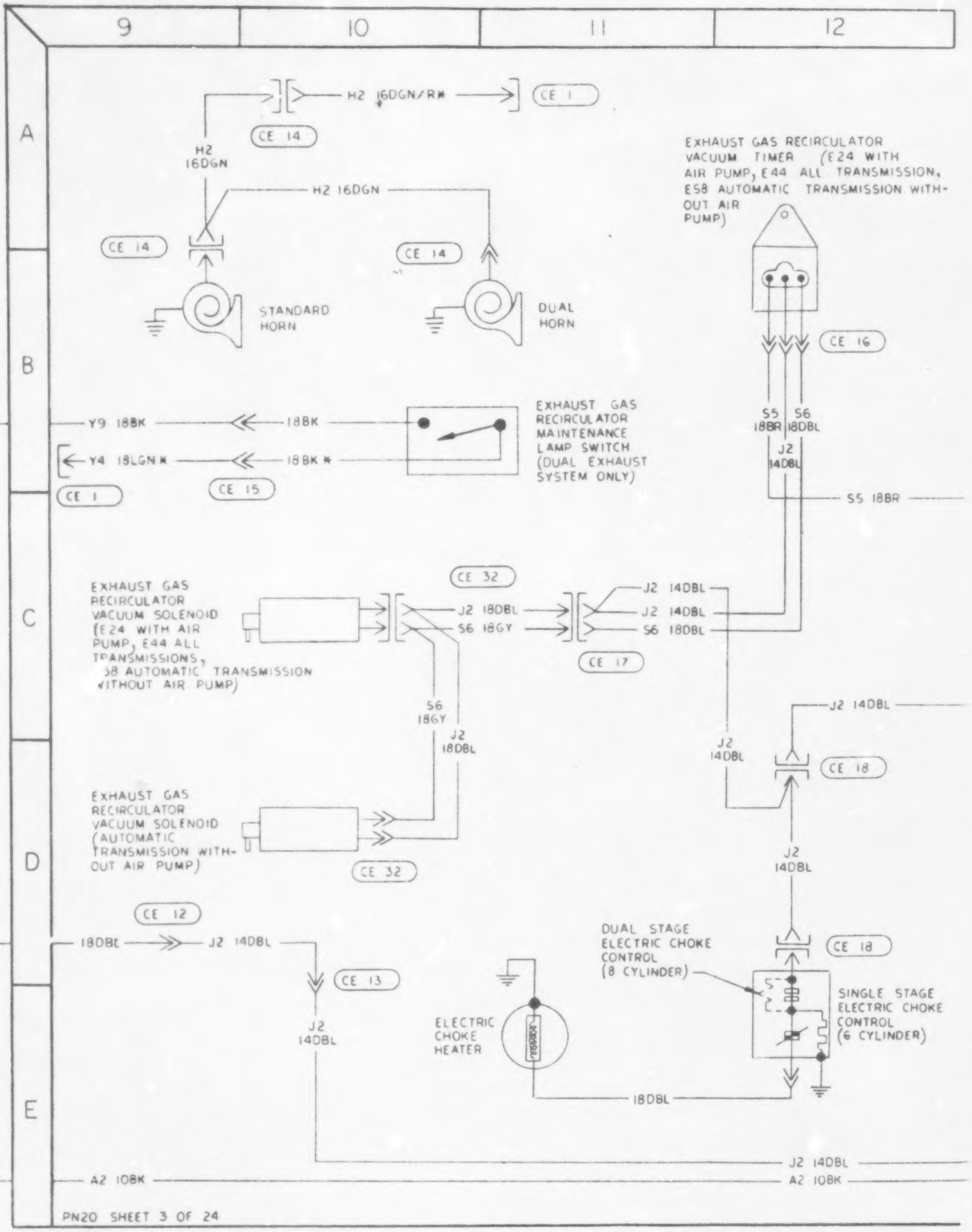
NAME	ZONE LOCATION
Flashers:	
Hazard	59C
Turn Signal	61C
Fusible Link	19C, 21A, 23B
Gauges:	
Ammeter	55B
Fuel	51D
Temperature	51C
Heated Rear Window	83B
Heater Resistor Block	80B
Horn	10B
Ignition Coil	16C
Lamps:	
Air Conditioning Switch Lamp	54E
Ash Tray Lamp	55B
Back-Up-Lamp-Left	87C
Right	87B
Brake Warning Lamp	50B
Console Lamp	84E
Dome Lamp	96D
Exhaust Gas Recirculation Lamp	44B
Gear Shift Selector Lamp	57D
Glove Box Lamp	67A
Head Lamp—Left	2C
Right	2C
eated Rear Window Indicator Lamp	70A
High Beam Indicator Lamp	53C
Ignition Switch Lamp	63D
Instrument Cluster Lamps	53D, 54D
License Lamp	87B
Map Lamps	57B
Oil Pressure Indicator Lamp	51B
Park and Turn Signal Lamp—Left	2E
Right	2A
Reverse Gear Indicator Lamp	46E
Seat Belt Warning Lamp	50E
Side Marker, Lamps, Front—Left	5C
Right	5C
Side Marker Lamps, Rear—Left	87C
Right	87A
Tail, Stop and Turn Signal Lamp—Left	87C
Right	87A
Taxi Open Door Indicator Lamp	67B
Trunk Lamp	95E
Turn Signal Indicator Lamp—Left	53C
Right	54C
Left Fender Top	2D
Right Fender Top	2B
Motors:	
Air Conditioning Blower Motor	27B
Heater Blower Motor	80B
Rear Window Defogger Blower Motor	91B
Starter Motor	19B
Windshield Washer Motor	25B
Windshield Wiper Motor (2 speed)	37B
Windshield Wiper Motor (3 speed)	39B
Radio	71E

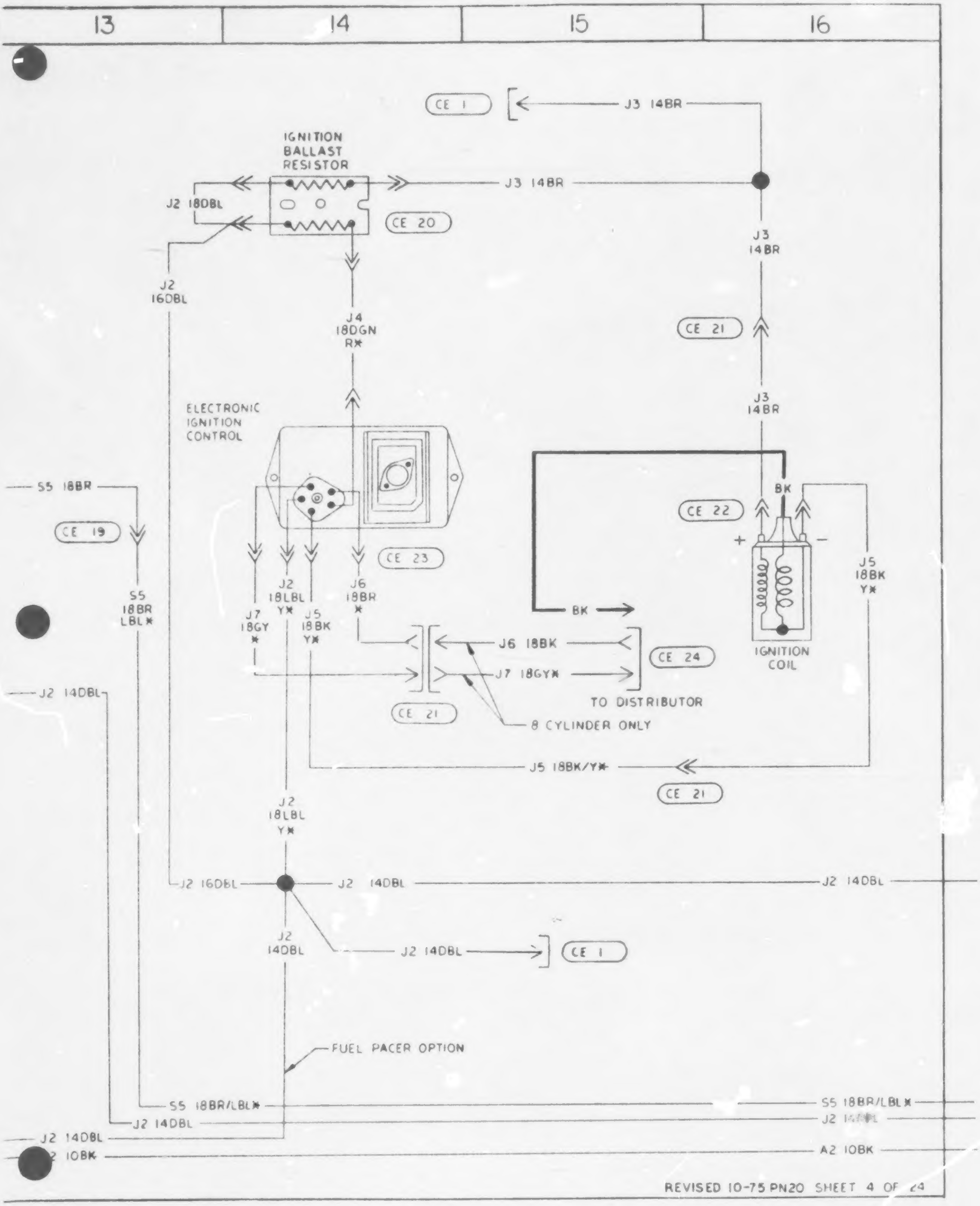
NAME	ZONE LOCATION
Rear Window Defogger Blower Motor Resistor	90B
Relays:	
Heated Rear Window Relay	71B
Horn Relay	59A
Starter Relay	28D
Time Delay Relay	62D
Seat Belt—Key In Buzzer	45E
Seat Belt Interlock Control Unit	43C
Sending Units:	
Fuel	37D
Temperature	34D
Speakers:	
Front	70C
Rear	96B
Switches:	
Air Conditioning Blower Motor Switch	78D
Air Conditioning Low Pressure Switch	35B
Air Conditioning Vacuum Switch	79C, 80C
Back-up Lamp Switch:	
Automatic Transmission	29C
Manual Transmission	30C, 32C
Brake Warning Switch	35D
Clutch Start Switch	25C
Defogger Switch	67E
Door Switch Front—Left	45B
Right	69D
Exhaust Gas Recirculation Maintenance Reminder Lamp Switch	10B
Fuel Pacer Vacuum Switch	8D
Door Switch Rear—Left	96C
Right	96C
Fader Switch	71D
Foot Dimmer Switch	48D
Glove Box Lamp Switch	68A
Hand Brake Release Switch	49D
Hazard Flasher Switch	61B
Headlight Switch	47B
Heated Rear Window Switch	71B
Heated Blower Switch	78B
Horn Switch	60B
Key Switch	46C
Low Oil Pressure	33D
Map Lamp Switch	58C
Neutral Starter Switch	29C
Seat Belt Buckle Switches	94E
Start and Ignition Switch	42B, 42C
Stop Lamp Switch (Std.)	59C
Trunk Lamp Switch	96D
Turn Signal Switch	62B, 63B
Windshield Wiper Switch (2-Speed)	73D, 74D
Windshield Wiper Switch (3-Speed)	75D, 76D
Trailer Towing	88D
Voltage Limiter	52C
Voltage Regulator	18C


1
2
3
4
A
B
C
D
E
RIGHT FRONT PARK AND TURN SIGNAL LAMP
L6 18BK/Y*
L9 18BK
D5 18BK/T*
L6 18BK/Y*
L9 18BK
CE 6
D5 18BK/T*
WITHOUT FENDER TOP TURN SIGNAL
RIGHT FRONT FENDER TOP TURN SIGNAL INDICATOR LAMP
18BK
D5 18BK/T*
D5 18BK/T*
CE 1
CE 4
L9 18BK
CE 2
RIGHT HEADLIGHT
L9 18BK
L9 18BK
L4 18V*
L3 18R
L9 18BK
CE 3
LEFT HEADLIGHT
L9 18BK
L9 18BK
L4 18V*
L4 18V*
L3 18R
L3 18R
L9 18BK
L9 18BK
L4 18V*
L3 18R
CE 1
WITHOUT FENDER TOP TURN SIGNAL
CE 5
CE 11
LEFT FRONT FENDER TOP TURN SIGNAL INDICATOR LAMP
18BK
D6 18BK/LGN*
D6 18BK/LGN*
D6 18BK/LGN*
CE 1
FUEL PACER OPTION
D6 18BK/LGN*
D6 18BK/O*
D6 18BK LGN*
CE 7
LEFT FRONT PARK AND TURN SIGNAL LAMP
D6 18BK/LGN*
L9 18BK
L6 18BK/Y*
L9 18BK
L6 18BK/Y*

PN20 SHEET 1 OF 24


5
6
7
8
L6 18BK/Y*
L9 18BK
L9 18BK
L9 18BK
L9 18BK
L9 18BK
RIGHT FRONT SIDE MARKER LAMP
L9 18BK
L6 18BK/Y*
CE 8
L6 18BK Y*
L9 18BK
L9 18BK
L9 18BK
Y9 18BK
A2 10BK
CE 1
L6 18BK/Y*
CE 9
L9 18BK
L6 18BK/Y*
L6 18BK Y*
L9 18BK
LEFT FRONT SIDE MARKER LAMP
CE 10
HEADLIGHT GROUND
DIODE
DIODE
RESISTOR
FUEL PACER VACUUM SWITCH
D6 18BK/LGN*
D6 18BK/O*
D6 18BK/LGN*
18BK
18DBL
CE 12
A2 10BK
L9 18BK
L6 18BK/Y*
PN20 SHEET 2 OF 24


9
10
11
12
A
B
C
D
E
H2 16DGN/R*
CE 1
CE 14
H2 16DGN
H2 16DGN
CE 14
CE 14
STANDARD HORN
DUAL HORN
EXHAUST GAS RECIRCULATOR VACUUM TIMER (E24 WITH AIR PUMP, E44 ALL TRANSMISSION, E58 AUTOMATIC TRANSMISSION WITHOUT AIR PUMP)
CE 16
Y9 18BK
18BK
Y4 18LGN*
18BK*
CE 1
CE 15
EXHAUST GAS RECIRCULATOR MAINTENANCE LAMP SWITCH (DUAL EXHAUST SYSTEM ONLY)
S5 18BR
S6 18DBL
J2 14DBL
S5 18BR
EXHAUST GAS RECIRCULATOR VACUUM SOLENOID (E24 WITH AIR PUMP, E44 ALL TRANSMISSIONS, E58 AUTOMATIC TRANSMISSION WITHOUT AIR PUMP)
CE 32
J2 18DBL
S6 18GY
J2 14DBL
J2 14DBL
S6 18DBL
CE 17
S6 18GY
J2 18DBL
J2 14DBL
J2 14DBL
CE 18
EXHAUST GAS RECIRCULATOR VACUUM SOLENOID (AUTOMATIC TRANSMISSION WITHOUT AIR PUMP)
CE 32
J2 14DBL
CE 12
18DBL
J2 14DBL
CE 13
J2 14DBL
DUAL STAGE ELECTRIC CHOKE CONTROL (8 CYLINDER)
CE 18
SINGLE STAGE ELECTRIC CHOKE CONTROL (6 CYLINDER)
ELECTRIC CHOKE HEATER
18DBL
J2 14DBL
A2 10BK
A2 10BK
PN20 SHEET 3 OF 24


13
14
15
16
CE 1
J3 14BR
IGNITION BALLAST RESISTOR
J2 18DBL
J3 14BR
CE 20
J2 16DBL
J4 18DGN R*
J3 14BR
CE 21
J3 14BR
ELECTRONIC IGNITION CONTROL
S5 18BR
CE 19
S5 18BR LBL*
CE 23
J7 18GY *
J2 18LBL Y*
J5 18BK Y*
J6 18BR *
BK
CE 22
+
−
J5 18BK Y*
BK
J6 18BK
J7 18GY*
CE 24
TO DISTRIBUTOR
IGNITION COIL
CE 21
8 CYLINDER ONLY
J2 14DBL
J5 18BK/Y*
CE 21
J2 18LBL Y*
J2 16DBL
J2 14DBL
J2 14DBL
J2 14DBL
J2 14DBL
CE 1
FUEL PACER OPTION
S5 18BR/LBL*
S5 18BR/LBL*
J2 14DBL
J2 14DBL
J2 14DBL
A2 10BK
A2 10BK

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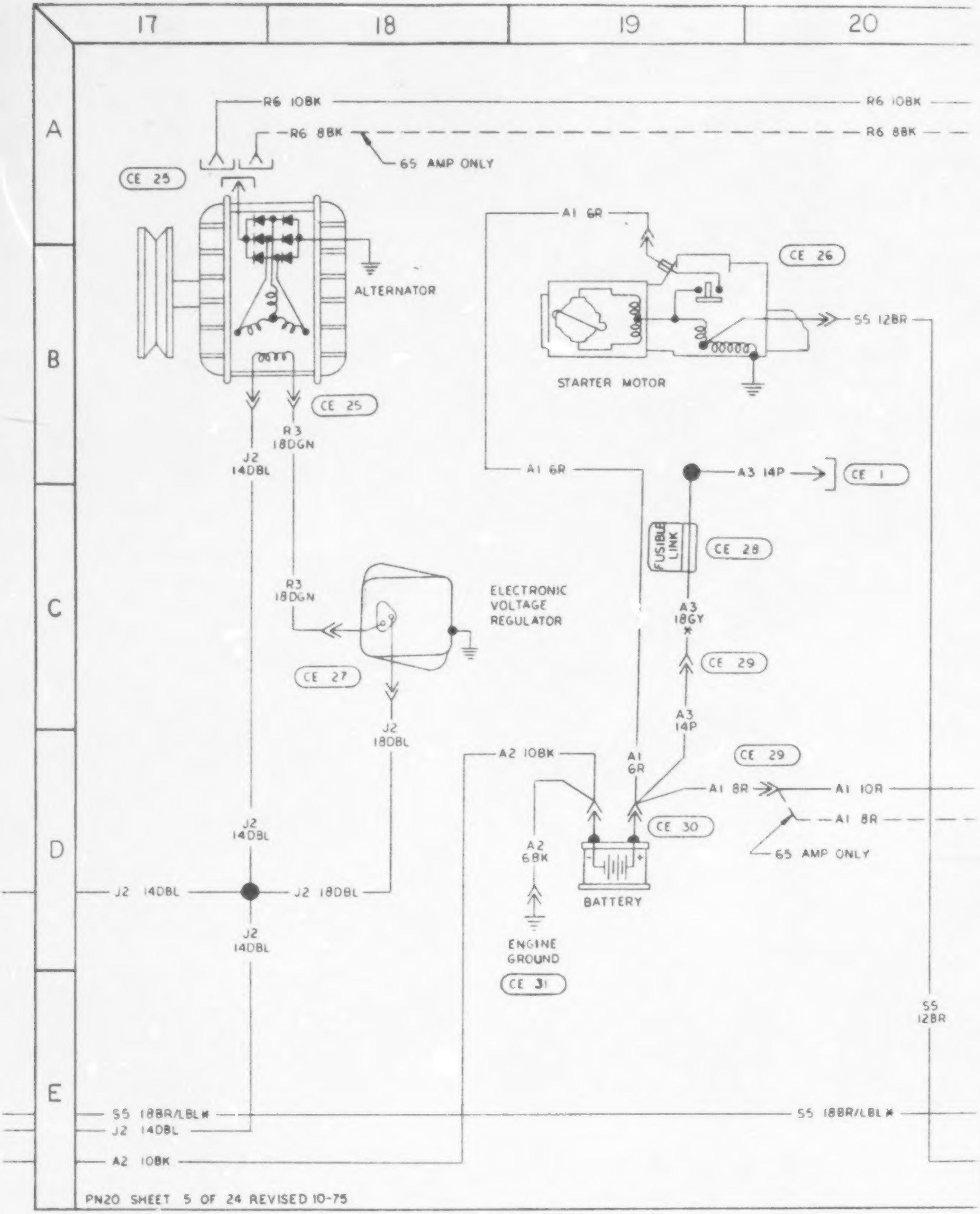
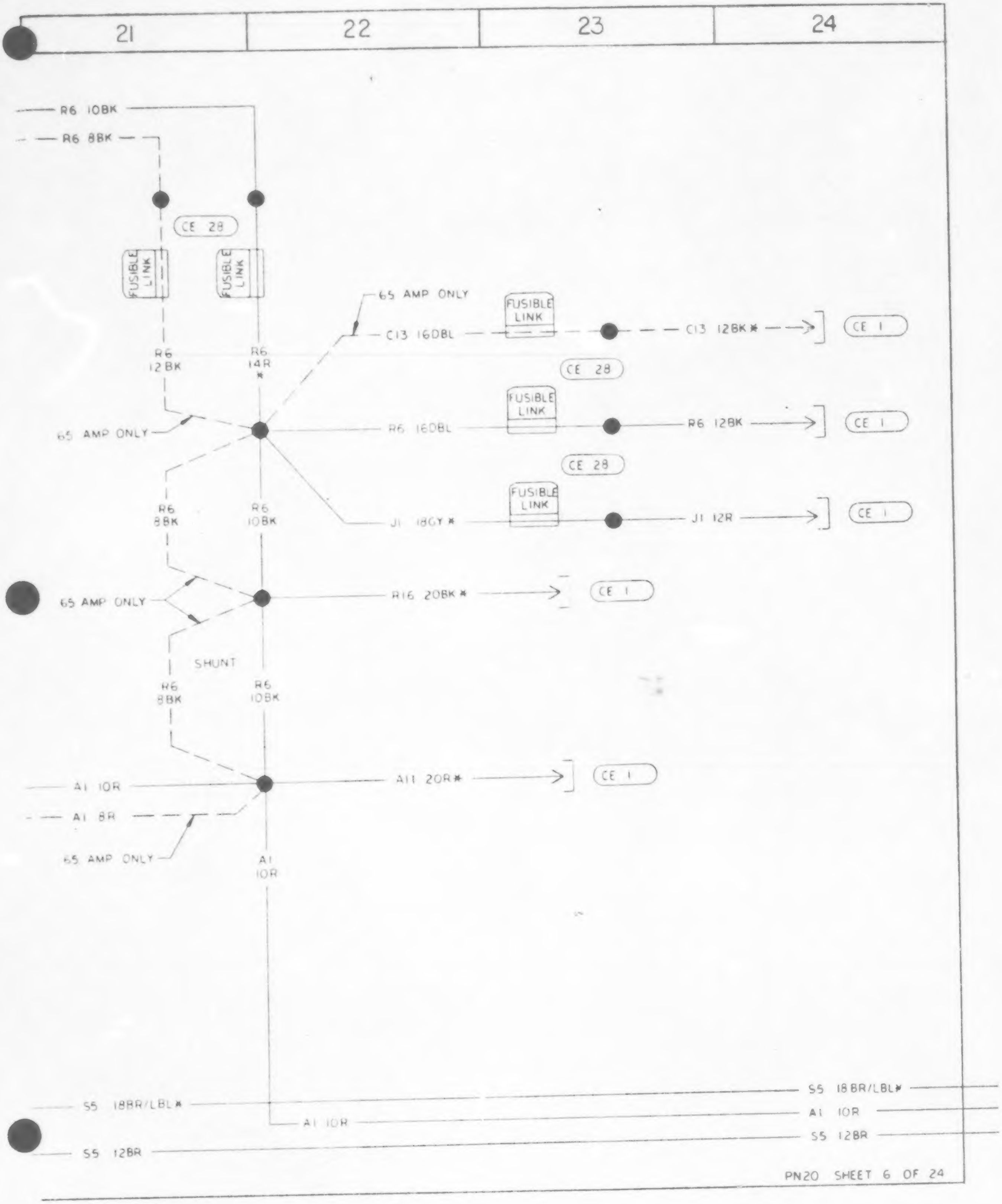
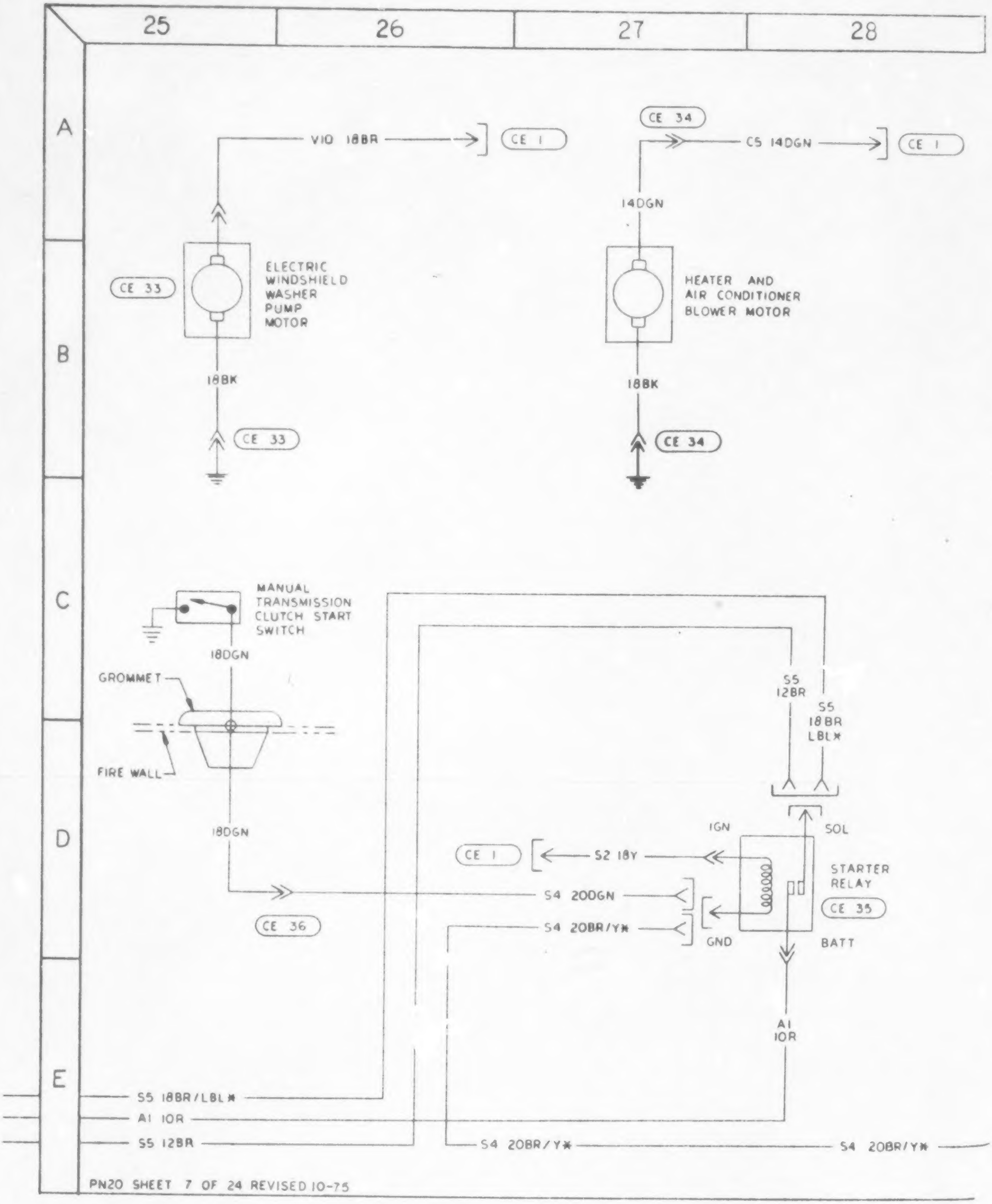

17
18
19
20
A
B
C
D
E
R6 10BK
R6 10BK
R6 8BK
R6 8BK
65 AMP ONLY
CE 25
ALTERNATOR
CE 25
R3
18DGN
J2
14DBL
A1 6R
CE 26
STARTER MOTOR
S5 12BR
A1 6R
A3 14P
CE 1
FUSIBLE LINK
CE 28
A3
18GY
*
CE 29
R3
18DGN
ELECTRONIC
VOLTAGE
REGULATOR
CE 27
J2
18DBL
A3
14P
A2 10BK
A1
6R
CE 29
A1 8R
A1 10R
A1 8R
65 AMP ONLY
CE 30
A2
6BK
BATTERY
ENGINE
GROUND
CE 31
J2
14DBL
J2 14DBL
J2 18DBL
J2
14DBL
S5
12BR
S5 18BR/LBL*
S5 18BR/LBL*
J2 14DBL
A2 10BK

PN20 SHEET 5 OF 24 REVISED 10-75


21
22
23
24
R6 10BK
R6 8BK
CE 28
FUSIBLE LINK
FUSIBLE LINK
65 AMP ONLY
C13 16DBL
FUSIBLE LINK
C13 12BK*
CE 1
R6 12BK
R6 14R *
CE 28
65 AMP ONLY
R6 16DBL
FUSIBLE LINK
R6 12BK
CE 1
CE 28
FUSIBLE LINK
J1 18GY*
J1 12R
CE 1
R6 8BK
R6 10BK
65 AMP ONLY
R16 20BK*
CE 1
SHUNT
R6 8BK
R6 10BK
A1 10R
A11 20R*
CE 1
A1 8R
65 AMP ONLY
A1 10R
S5 18BR/LBL*
A1 10R
S5 12BR
S5 18BR/LBL*
A1 10R
S5 12BR

PN20 SHEET 6 OF 24


25
26
27
28
A
B
C
D
E
V10 18BR
CE 1
CE 33
ELECTRIC WINDSHIELD WASHER PUMP MOTOR
18BK
CE 33
CE 34
C5 14DGN
CE 1
14DGN
HEATER AND AIR CONDITIONER BLOWER MOTOR
18BK
CE 34
MANUAL TRANSMISSION CLUTCH START SWITCH
18DGN
GROMMET
FIRE WALL
18DGN
S5 12BR
S5 18BR LBL*
IGN
SOL
CE 1
S2 18Y
STARTER RELAY
S4 20DGN
CE 35
S4 20BR/Y*
GND
BATT
CE 36
A1 10R
S5 18BR/LBL*
A1 10R
S5 12BR
S4 20BR/Y*
S4 20BR/Y*
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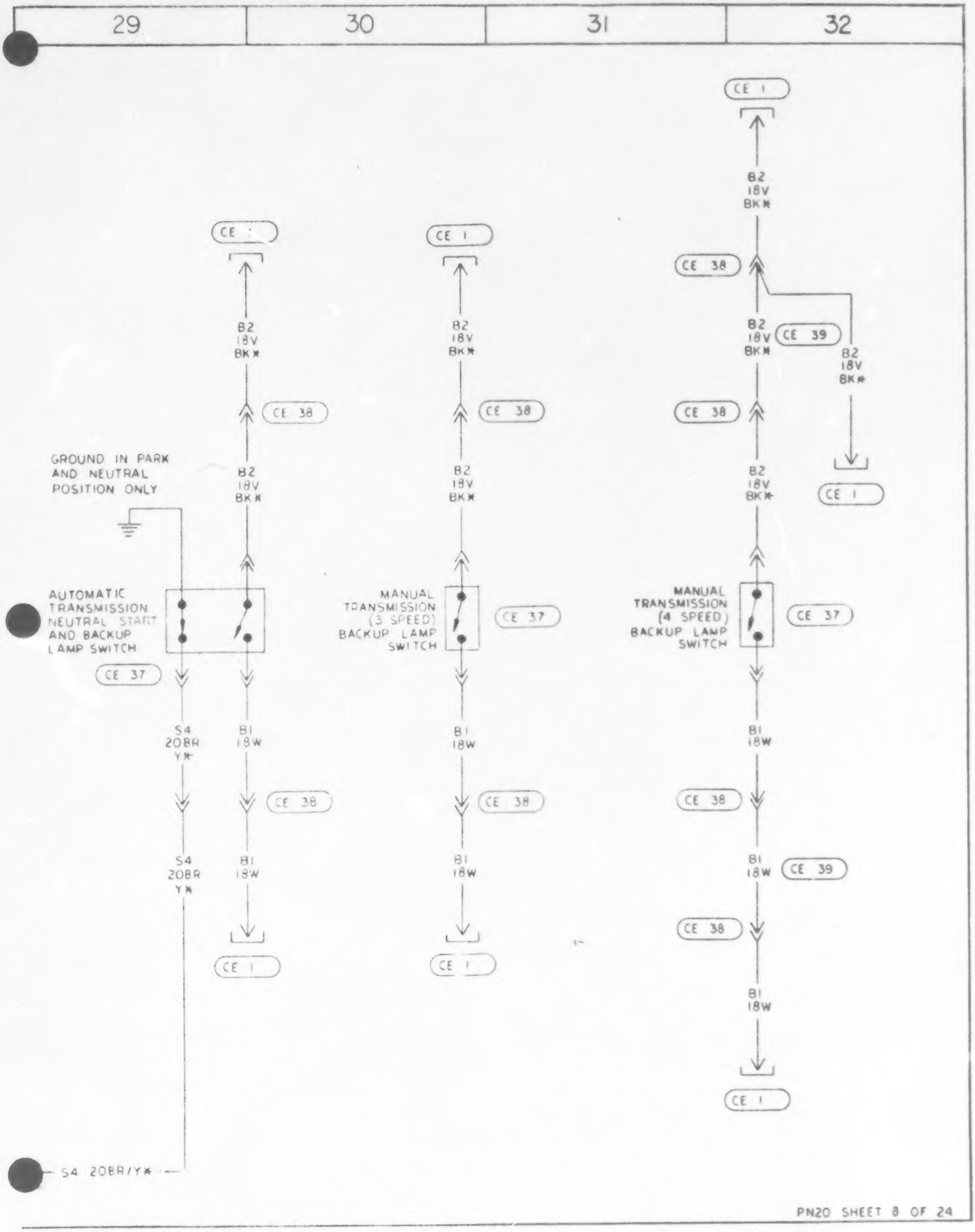
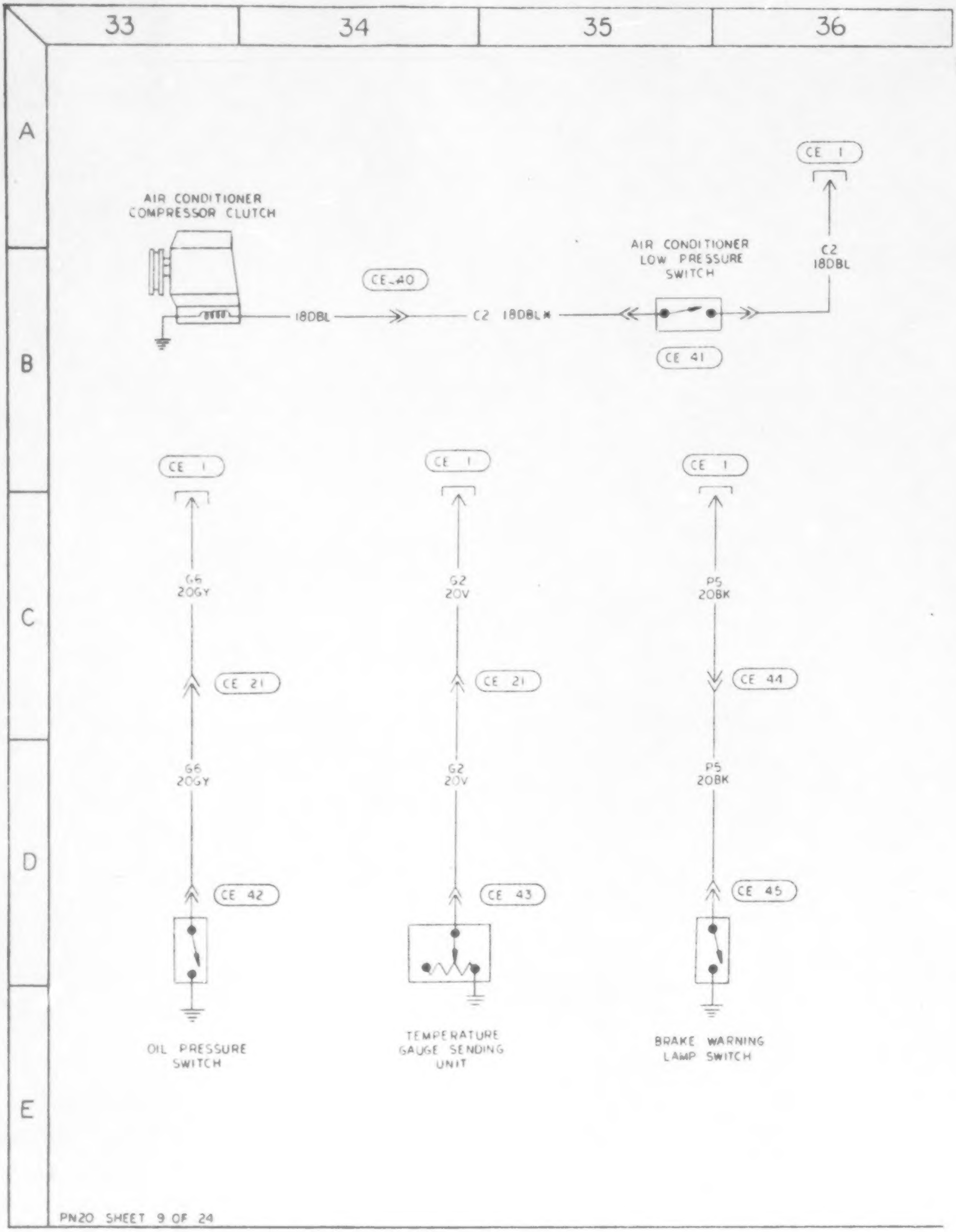
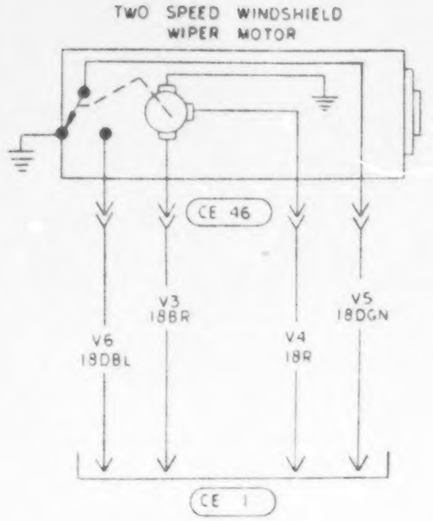
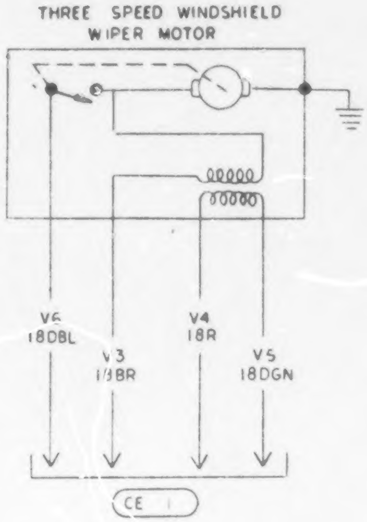

29
30
31
32
CE 1
B2
18V
BK*
CE 38
GROUND IN PARK AND NEUTRAL POSITION ONLY
AUTOMATIC TRANSMISSION NEUTRAL START AND BACKUP LAMP SWITCH
CE 37
S4
20BR
Y*
B1
18W
CE 38
CE 1
MANUAL TRANSMISSION (3 SPEED) BACKUP LAMP SWITCH
CE 37
MANUAL TRANSMISSION (4 SPEED) BACKUP LAMP SWITCH
CE 39
S4 20BR/Y*

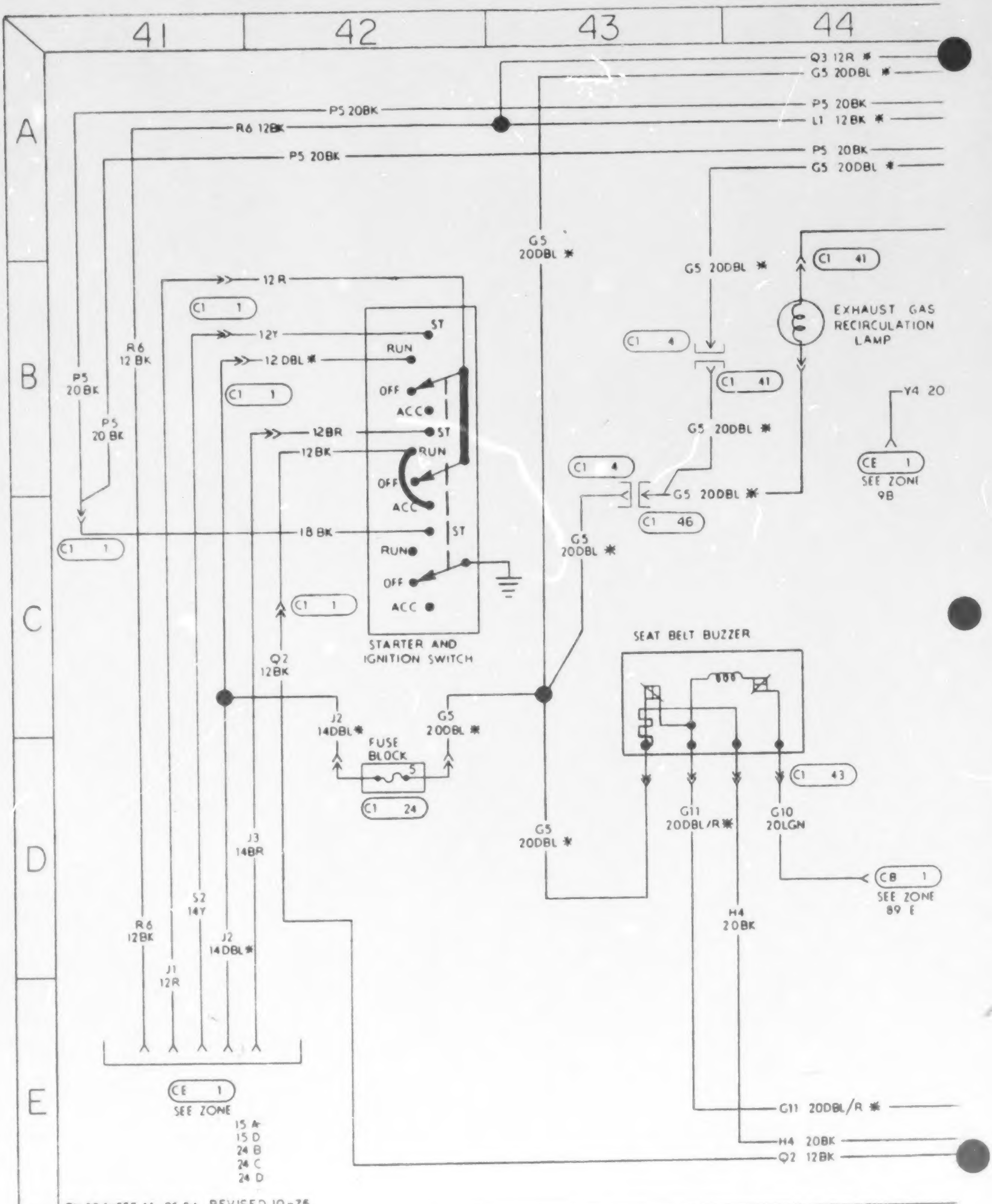
669


33
34
35
36
A
B
C
D
E
AIR CONDITIONER COMPRESSOR CLUTCH
18DBL
CE-40
C2 18DBL*
AIR CONDITIONER LOW PRESSURE SWITCH
CE 41
CE 1
C2 18DBL
CE 1
G6 20GY
CE 21
G6 20GY
CE 42
OIL PRESSURE SWITCH
CE 1
G2 20V
CE 21
G2 20V
CE 43
TEMPERATURE GAUGE SENDING UNIT
CE 1
P5 20BK
CE 44
P5 20BK
CE 45
BRAKE WARNING LAMP SWITCH
PN20 SHEET 9 OF 24

37	38	39	40


TWO SPEED WINDSHIELD
WIPER MOTOR
CE 46
V6
18DBL
V3
18BR
V4
18R
V5
18DGN
CE 1


THREE SPEED WINDSHIELD
WIPER MOTOR
V6
18DBL
V3
18BR
V4
18R
V5
18DGN
CE 1


41
42
43
44
A
B
C
D
E
Q3 12R ✱
G5 20DBL ✱
P5 20BK
L1 12BK ✱
P5 20BK
G5 20DBL ✱
P5 20BK
R6 12BK
P5 20BK
G5 20DBL ✱
G5 20DBL ✱
C1 41
EXHAUST GAS RECIRCULATION LAMP
C1 4
C1 41
G5 20DBL ✱
Y4 20
CE 1
SEE ZONE 9B
12 R
C1 1
12Y
ST
RUN
12 DBL ✱
C1 1
OFF
ACC
12BR
ST
12BK
RUN
OFF
ACC
18 BK
ST
RUN
OFF
ACC
C1 1
C1 1
STARTER AND IGNITION SWITCH
R6 12BK
P5 20BK
P5 20 BK
C1 4
G5 20DBL ✱
C1 46
G5 20DBL ✱
Q2 12BK
J2 14DBL ✱
FUSE BLOCK
5
C1 24
G5 20DBL ✱
SEAT BELT BUZZER
C1 43
G11 20DBL/R ✱
G10 20LGN
CB 1
SEE ZONE 89 E
G5 20DBL ✱
H4 20BK
J3 14BR
S2 14Y
R6 12BK
J2 14DBL ✱
J1 12R
CE 1
SEE ZONE
15 A
15 D
24 B
24 C
24 D
G11 20DBL/R ✱
H4 20BK
Q2 12BK

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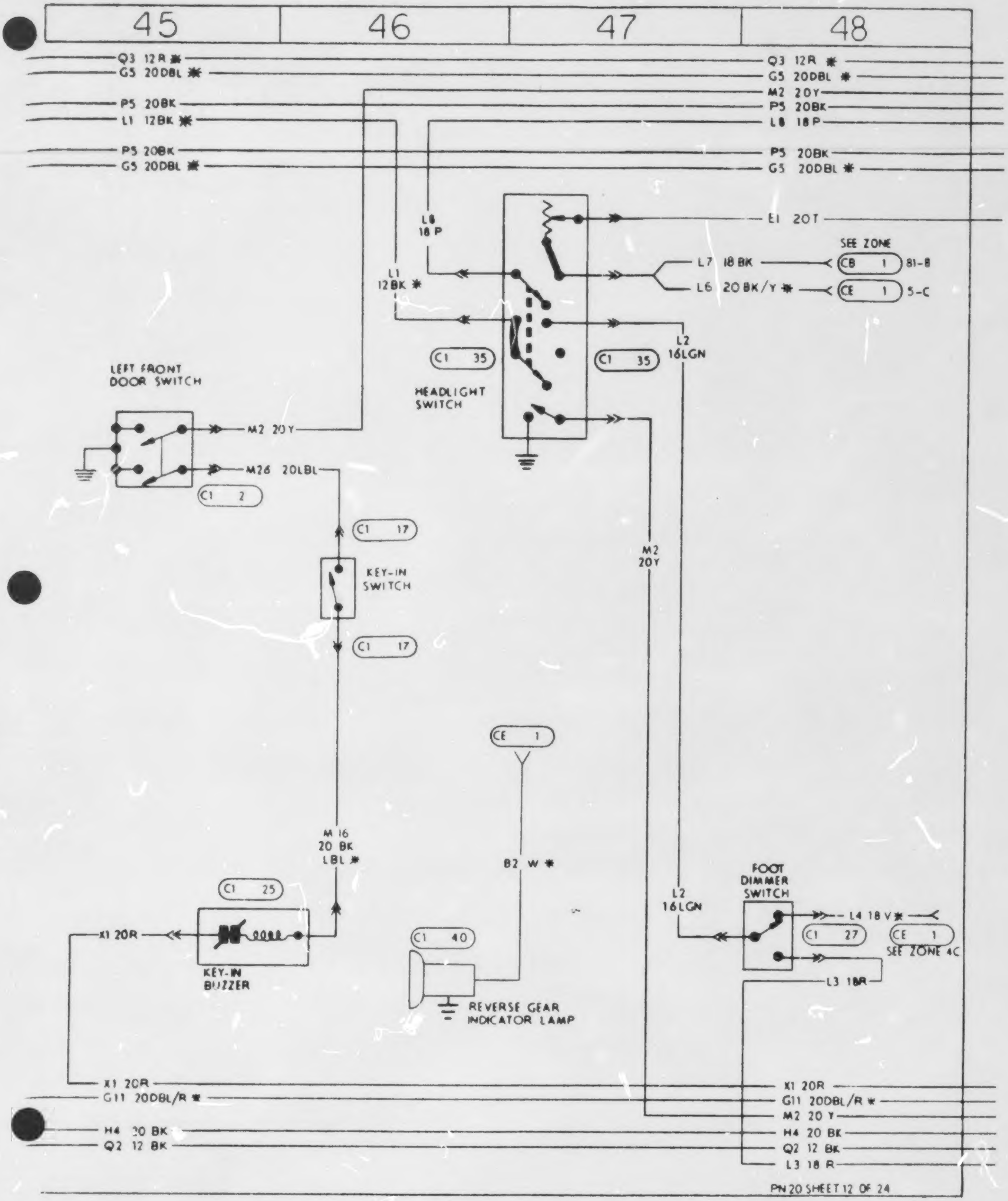
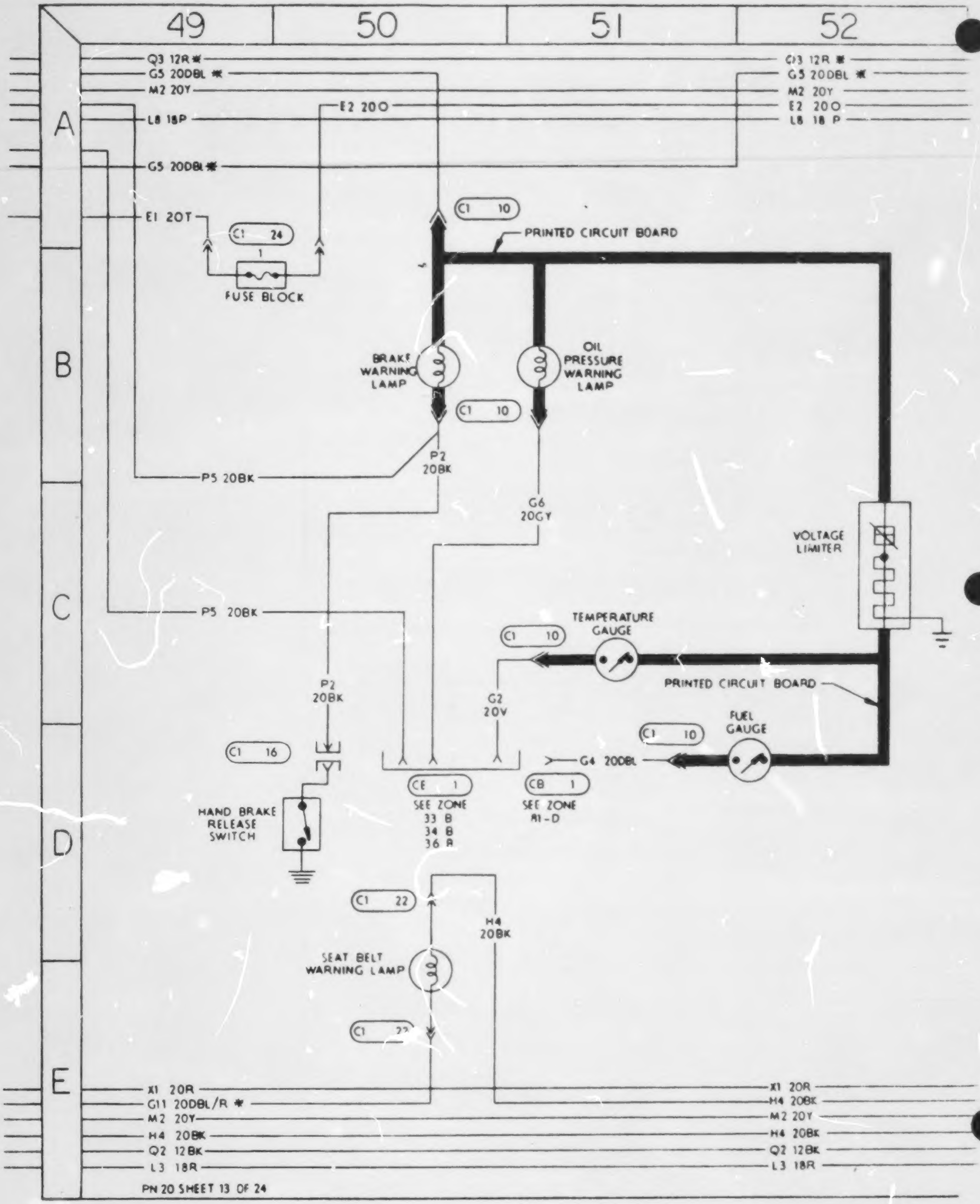
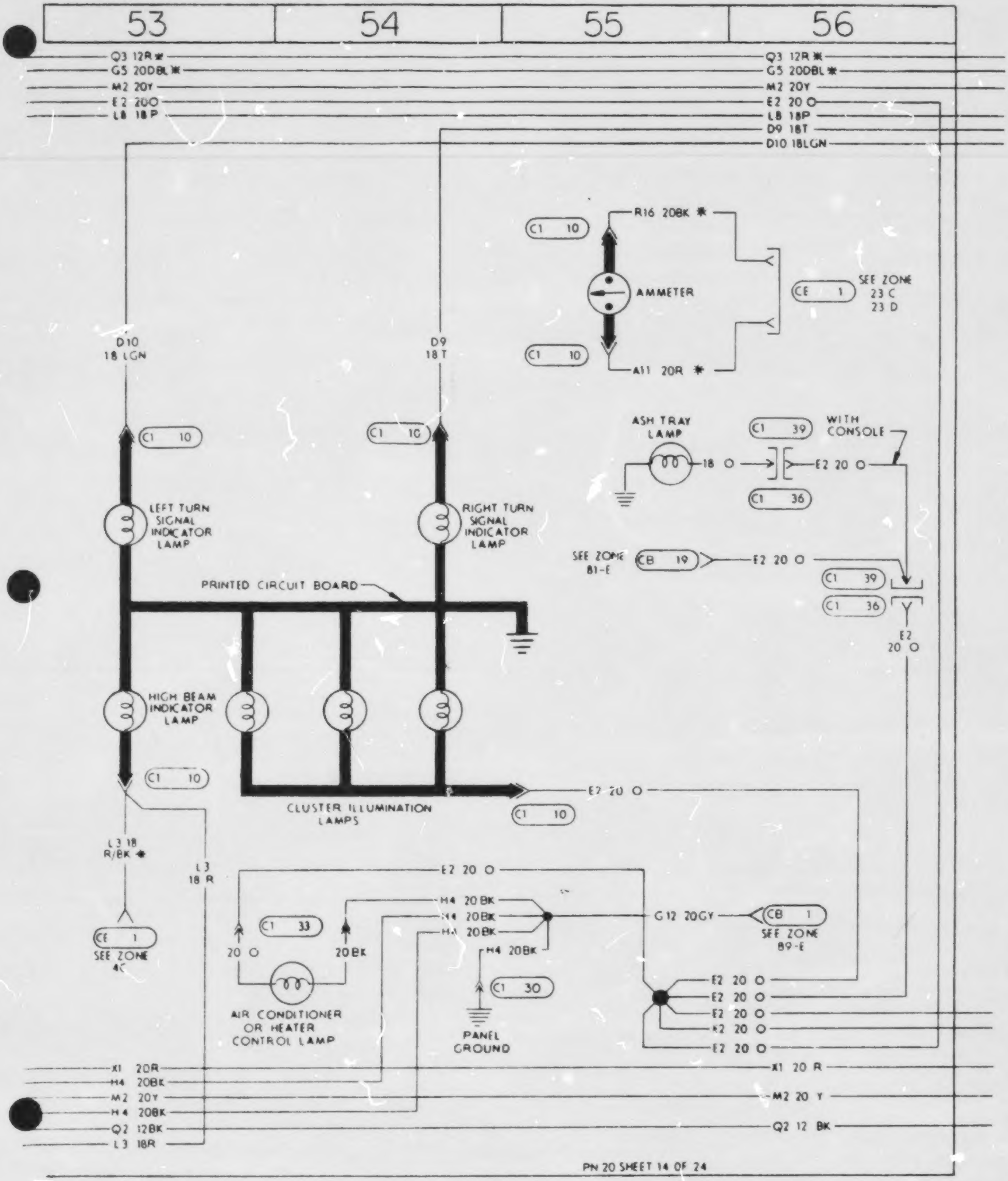

45
46
47
48
Q3 12R *
G5 20DBL *
P5 20BK
L1 12BK *
P5 20BK
G5 20DBL *
Q3 12R *
G5 20DBL *
M2 20Y
P5 20BK
L8 18P
P5 20BK
G5 20DBL *
E1 20T
L8 18 P
L1 12BK *
L7 18 BK
L6 20 BK/Y *
SEE ZONE
CB 1
81-B
CE 1
5-C
L2 16LGN
C1 35
C1 35
HEADLIGHT SWITCH
LEFT FRONT DOOR SWITCH
M2 20Y
M26 20LBL
C1 2
C1 17
KEY-IN SWITCH
C1 17
M2 20Y
CE 1
M16 20 BK LBL *
B2 W *
C1 25
X1 20R
KEY-IN BUZZER
C1 40
REVERSE GEAR INDICATOR LAMP
L2 16LGN
FOOT DIMMER SWITCH
L4 18 V *
C1 27
CE 1
SEE ZONE 4C
L3 18R
X1 20R
G11 20DBL/R *
H4 20 BK
Q2 12 BK
X1 20R
G11 20DBL/R *
M2 20 Y
H4 20 BK
Q2 12 BK
L3 18 R


49
50
51
52
A
B
C
D
E
Q3 12R *
G5 20DBL *
M2 20Y
L8 18P
E2 20O
G5 20DBL *
E1 20T
C1 24
1
FUSE BLOCK
C1 10
PRINTED CIRCUIT BOARD
BRAKE WARNING LAMP
OIL PRESSURE WARNING LAMP
C1 10
P2 20BK
P5 20BK
G6 20GY
VOLTAGE LIMITER
P5 20BK
TEMPERATURE GAUGE
C1 10
PRINTED CIRCUIT BOARD
P2 20BK
G2 20V
FUEL GAUGE
C1 10
C1 16
G4 20DBL
CE 1
SEE ZONE 33 B 34 B 36 A
CB 1
SEE ZONE 81-D
HAND BRAKE RELEASE SWITCH
C1 22
H4 20BK
SEAT BELT WARNING LAMP
C1 22
Q3 12R *
G5 20DBL *
M2 20Y
E2 20O
L8 18 P
X1 20R
G11 20DBL/R *
M2 20Y
H4 20BK
Q2 12BK
L3 18R
X1 20R
H4 20BK
M2 20Y
H4 20BK
Q2 12BK
L3 18R
PN 20 SHEET 13 OF 24


53
54
55
56
Q3 12R ✱
G5 20DBL ✱
M2 20Y
E2 20O
L8 18P
D9 18T
D10 18LGN
R16 20BK ✱
C1 10
AMMETER
CE 1
SEE ZONE 23 C 23 D
A11 20R ✱
D10 18 LGN
D9 18 T
LEFT TURN SIGNAL INDICATOR LAMP
RIGHT TURN SIGNAL INDICATOR LAMP
ASH TRAY LAMP
18 O
C1 39
C1 36
WITH CONSOLE
E2 20 O
SEE ZONE 81-E
CB 19
PRINTED CIRCUIT BOARD
HIGH BEAM INDICATOR LAMP
CLUSTER ILLUMINATION LAMPS
L3 18 R/BK ✱
L3 18 R
CE 1
SEE ZONE 4C
C1 33
20 O
20BK
AIR CONDITIONER OR HEATER CONTROL LAMP
H4 20BK
G12 20GY
CB 1
SEE ZONE 89-E
C1 30
PANEL GROUND
X1 20R
H4 20BK
M2 20Y
Q2 12BK
L3 18R
X1 20 R
M2 20 Y
Q2 12 BK

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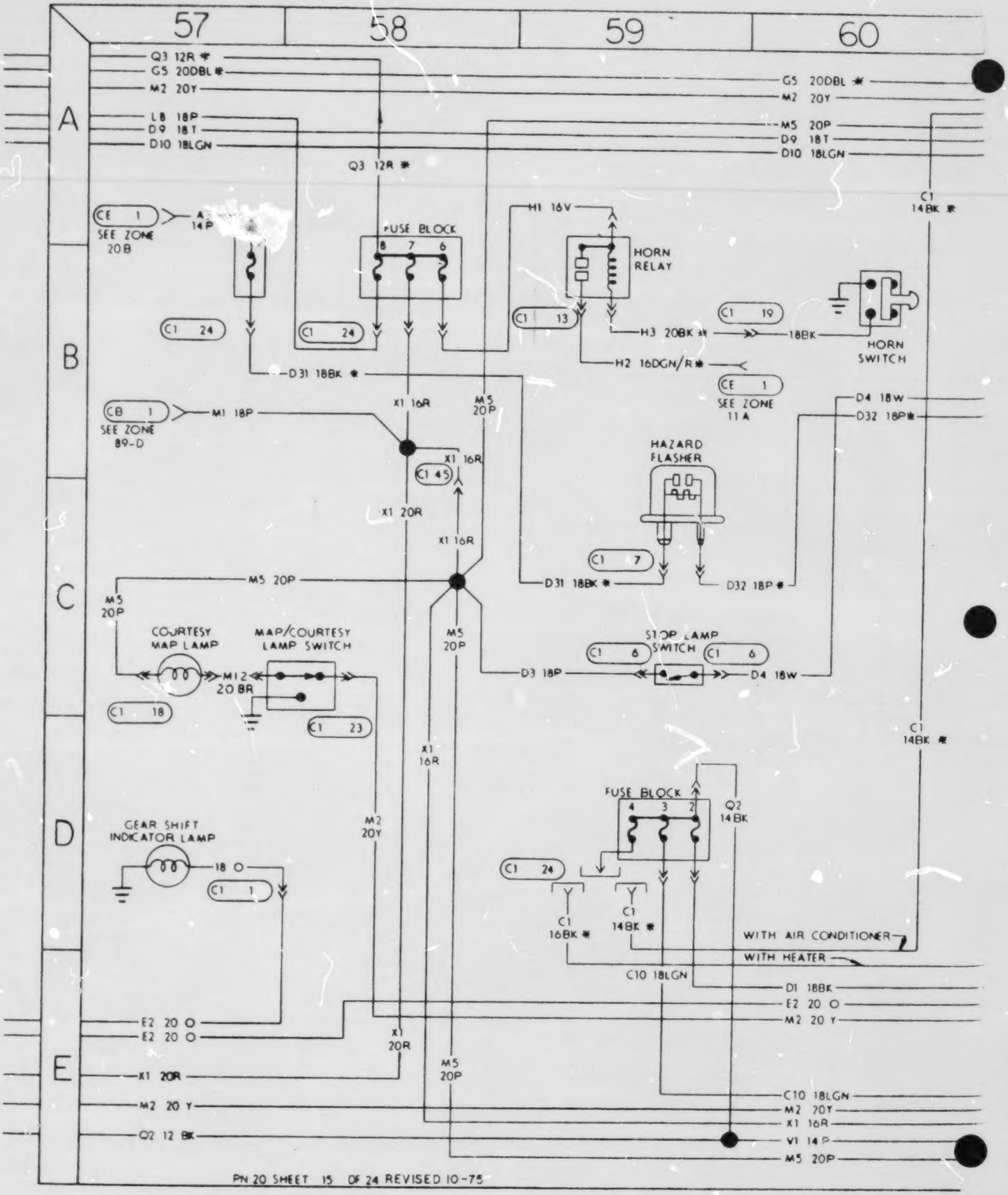
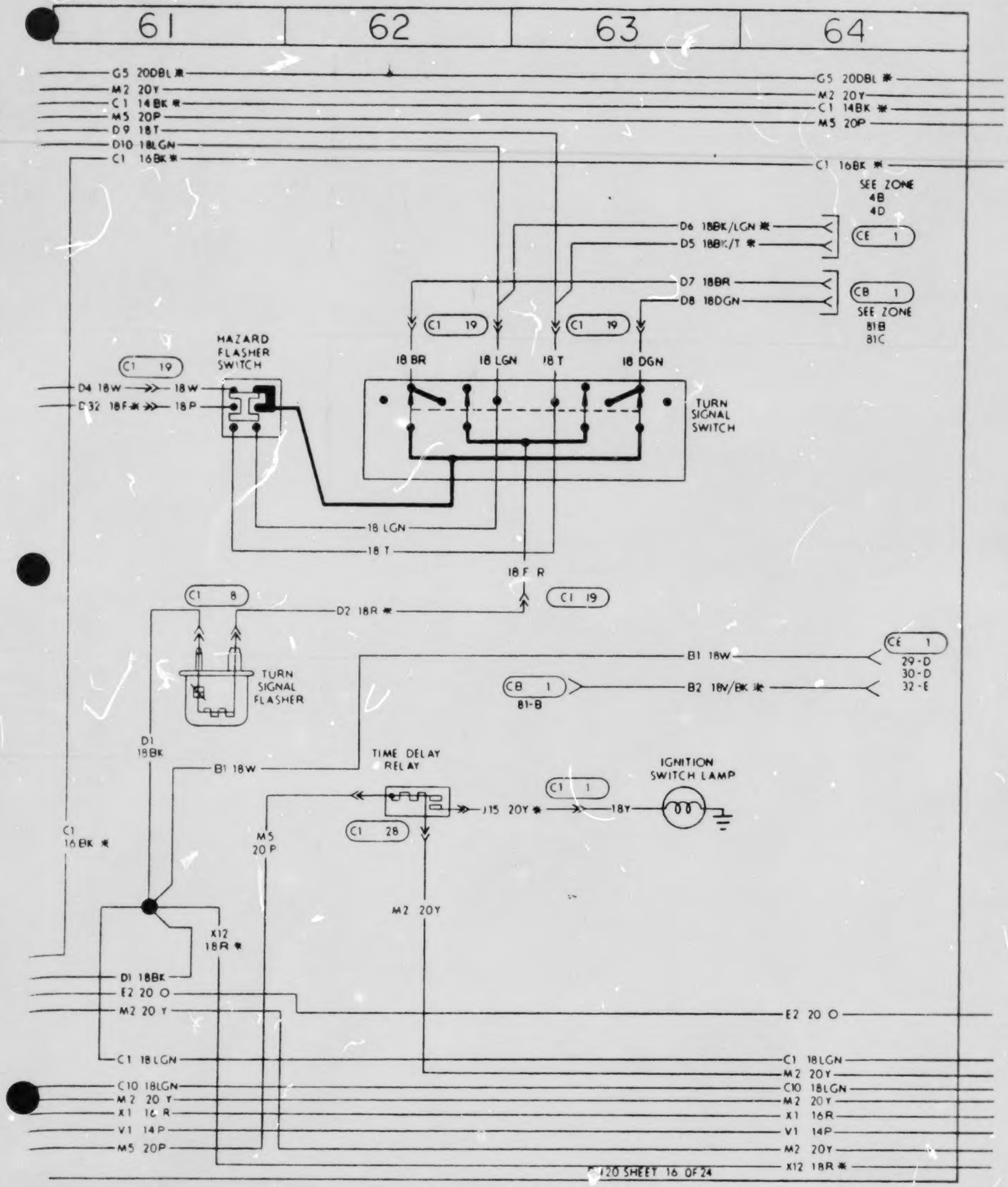
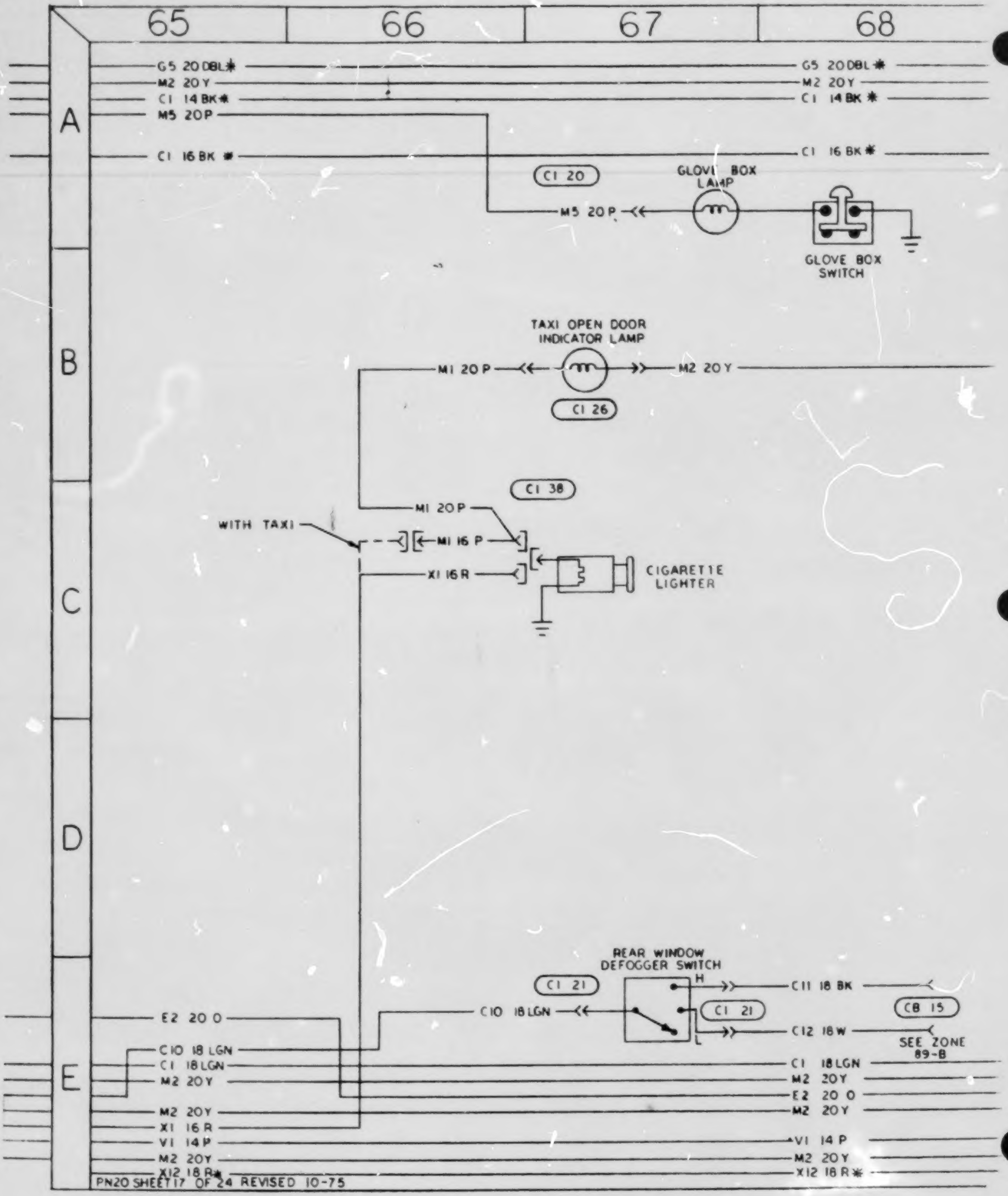
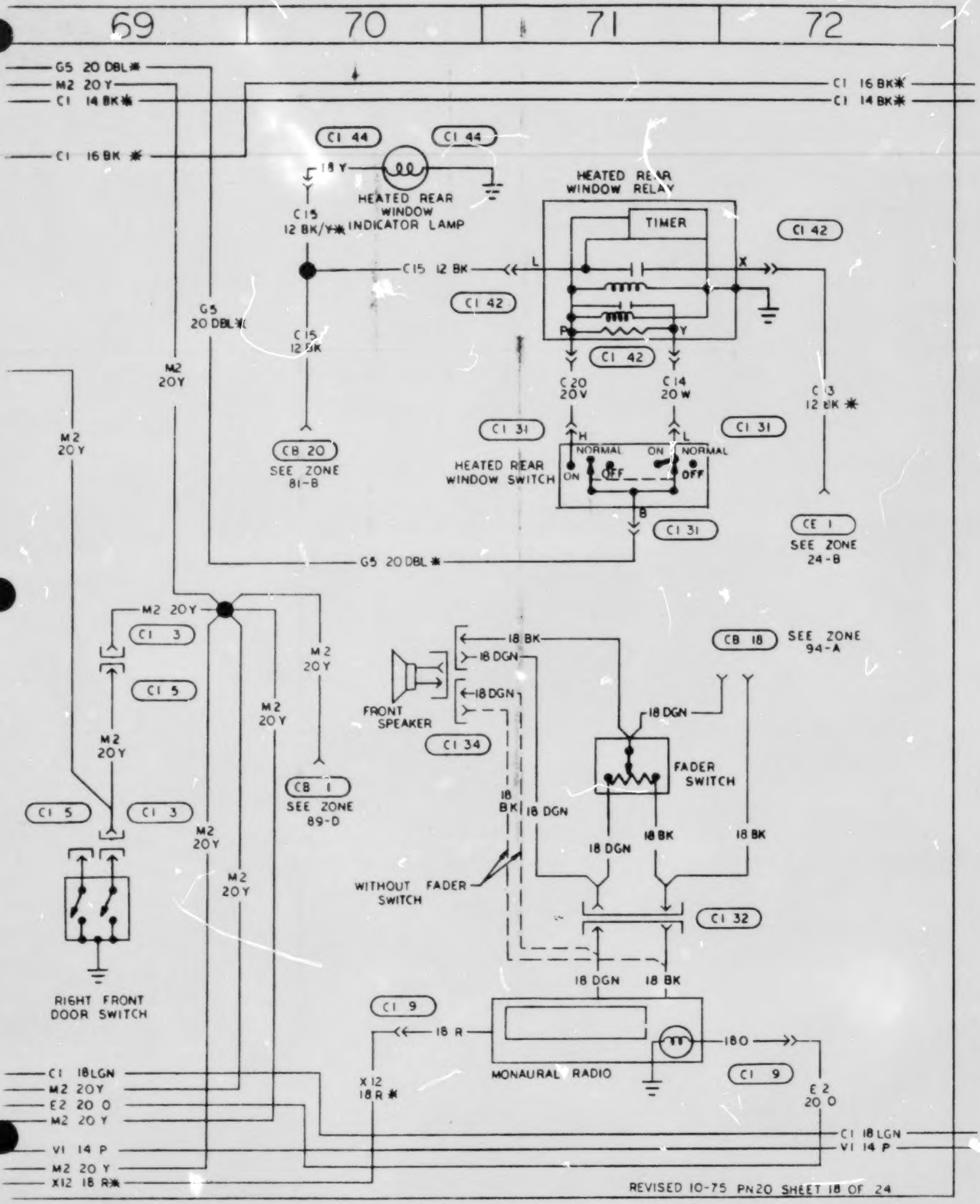

57
58
59
60
A
B
C
D
E
Q3 12R *
G5 20DBL *
M2 20Y
L8 18P
D9 18T
D10 18LGN
G5 20DBL *
M2 20Y
M5 20P
D9 18T
D10 18LGN
Q3 12R *
C1 14BK *
CE 1
SEE ZONE 20B
14P
FUSE BLOCK
8 7 6
H1 16V
HORN RELAY
C1 24
C1 24
C1 13
C1 19
H3 20BK *
18BK
HORN SWITCH
D31 18BK *
H2 16DGN/R *
CE 1
SEE ZONE 11A
D4 18W
D32 18P *
CB 1
SEE ZONE 89-D
M1 18P
X1 16R
M5 20P
X1 16R
C1 45
X1 20R
X1 16R
HAZARD FLASHER
C1 7
D31 18BK *
D32 18P *
M5 20P
M5 20P
COURTESY MAP LAMP
MAP/COURTESY LAMP SWITCH
M12 20BR
M5 20P
STOP LAMP SWITCH
C1 6
C1 6
D3 18P
D4 18W
C1 18
C1 23
C1 14BK *
X1 16R
FUSE BLOCK
4 3 2
Q2 14BK
M2 20Y
GEAR SHIFT INDICATOR LAMP
18 O
C1 1
C1 24
C1 16BK *
C1 14BK *
WITH AIR CONDITIONER
WITH HEATER
C10 18LGN
D1 18BK
E2 20 O
M2 20Y
E2 20 O
E2 20 O
X1 20R
M5 20P
X1 20R
C10 18LGN
M2 20Y
M2 20Y
X1 16R
Q2 12 BK
V1 14P
M5 20P

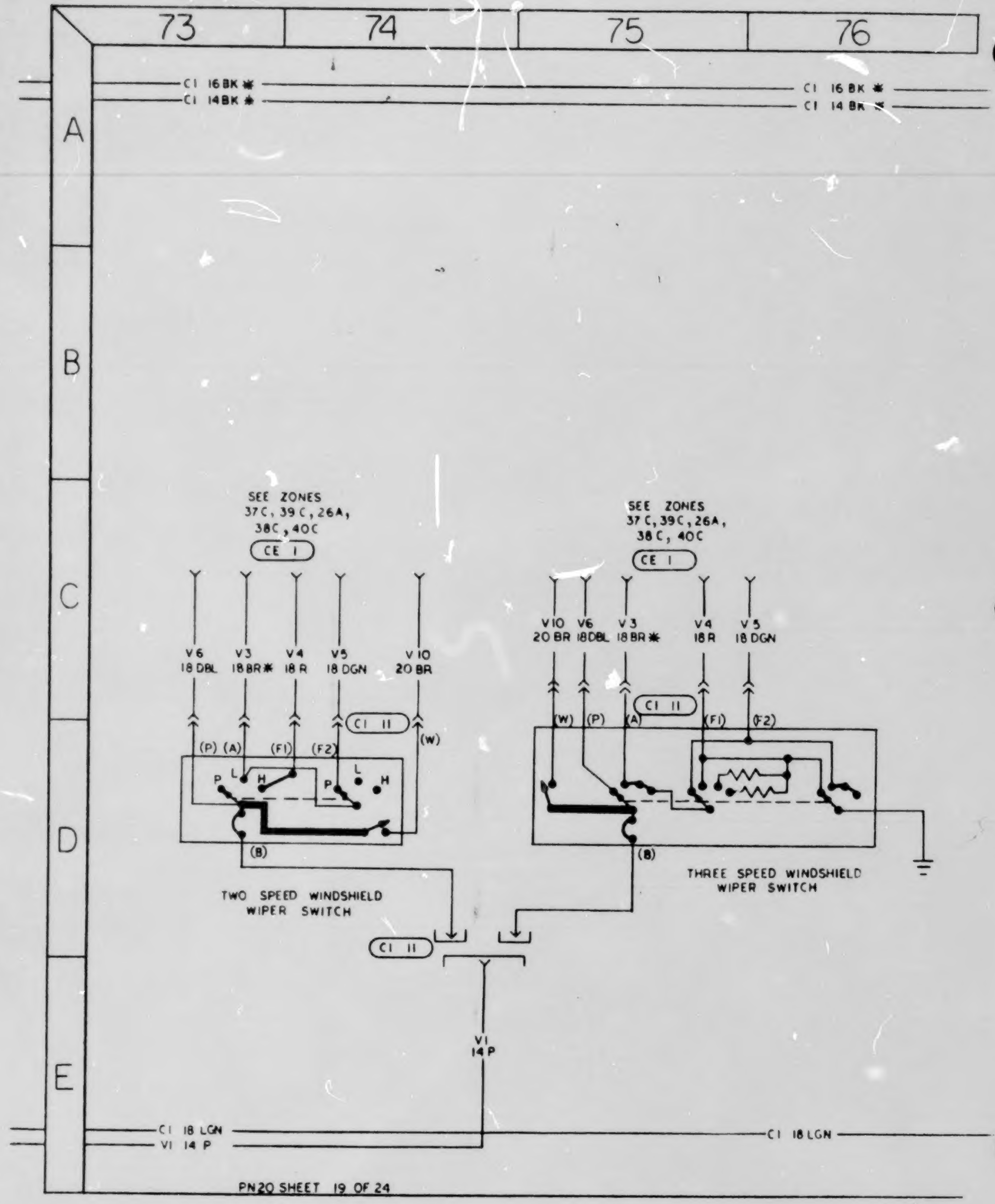
PN 20 SHEET 15 OF 24 REVISED 10-75

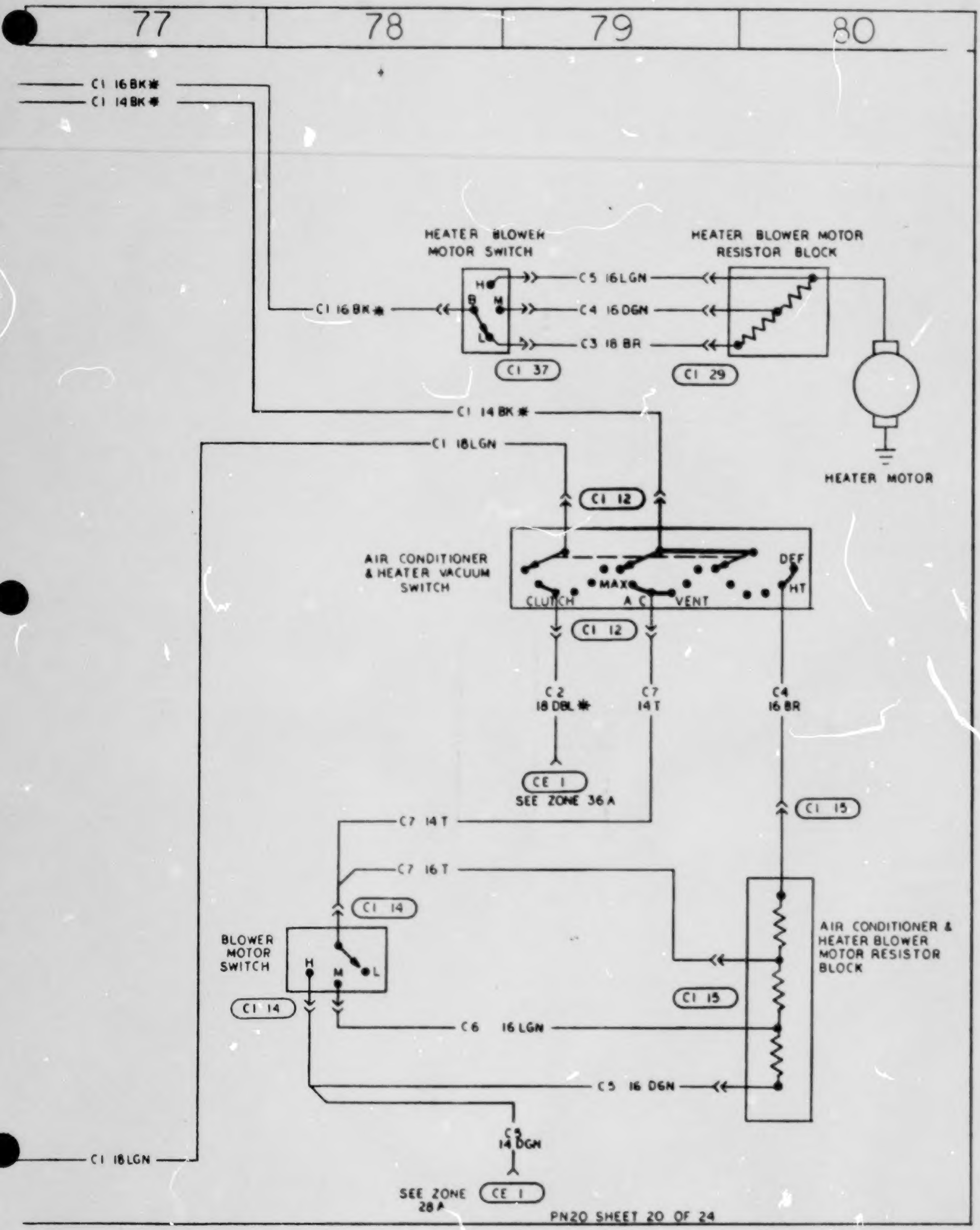

61
62
63
64
G5 20DBL ✱
M2 20Y
C1 14BK ✱
M5 20P
D9 18T
D10 18LGN
C1 16BK ✱
G5 20DBL ✱
M2 20Y
C1 14BK ✱
M5 20P
C1 16BK ✱
SEE ZONE
4B
4D
D6 18BK/LGN ✱
D5 18BK/T ✱
CE 1
D7 18BR
D8 18DGN
CB 1
SEE ZONE
81B
81C
C1 19
C1 19
18 BR
18 LGN
18 T
18 DGN
HAZARD
FLASHER
SWITCH
C1 19
D4 18W
18W
D32 18P ✱
18P
TURN
SIGNAL
SWITCH
18 LGN
18 T
18 F R
C1 19
C1 8
D2 18R ✱
TURN
SIGNAL
FLASHER
B1 18W
CE 1
29-D
30-D
32-E
CB 1
81-B
B2 18V/BK ✱
D1
18BK
B1 18W
TIME DELAY
RELAY
IGNITION
SWITCH LAMP
C1 1
J15 20Y ✱
18Y
C1 28
M5
20P
C1
16BK ✱
M2 20Y
X12
18R ✱
D1 18BK
E2 20 O
M2 20 Y
E2 20 O
C1 18LGN
C1 18LGN
M2 20Y
C10 18LGN
C10 18LGN
M2 20Y
M2 20Y
X1 16 R
X1 16R
V1 14P
V1 14P
M5 20P
M2 20Y
X12 18R ✱
8120 SHEET 16 OF 24


65
66
67
68
A
B
C
D
E
G5 20 DBL*
M2 20 Y
C1 14 BK*
M5 20 P
C1 16 BK *
G5 20 DBL *
M2 20 Y
C1 14 BK *
C1 16 BK *
C1 20
GLOVE BOX LAMP
M5 20 P
GLOVE BOX SWITCH
TAXI OPEN DOOR INDICATOR LAMP
M1 20 P
M2 20 Y
C1 26
C1 38
M1 20 P
WITH TAXI
M1 16 P
X1 16 R
CIGARETTE LIGHTER
REAR WINDOW DEFOGGER SWITCH
C1 21
H
L
C10 18 LGN
C1 21
C11 18 BK
C12 18 W
C8 15
SEE ZONE 89-B
E2 20 O
C10 18 LGN
C1 18 LGN
M2 20 Y
M2 20 Y
X1 16 R
V1 14 P
M2 20 Y
X12 18 R*
C1 18 LGN
M2 20 Y
E2 20 O
M2 20 Y
V1 14 P
M2 20 Y
X12 18 R*
PN20 SHEET 17 OF 24 REVISED 10-75

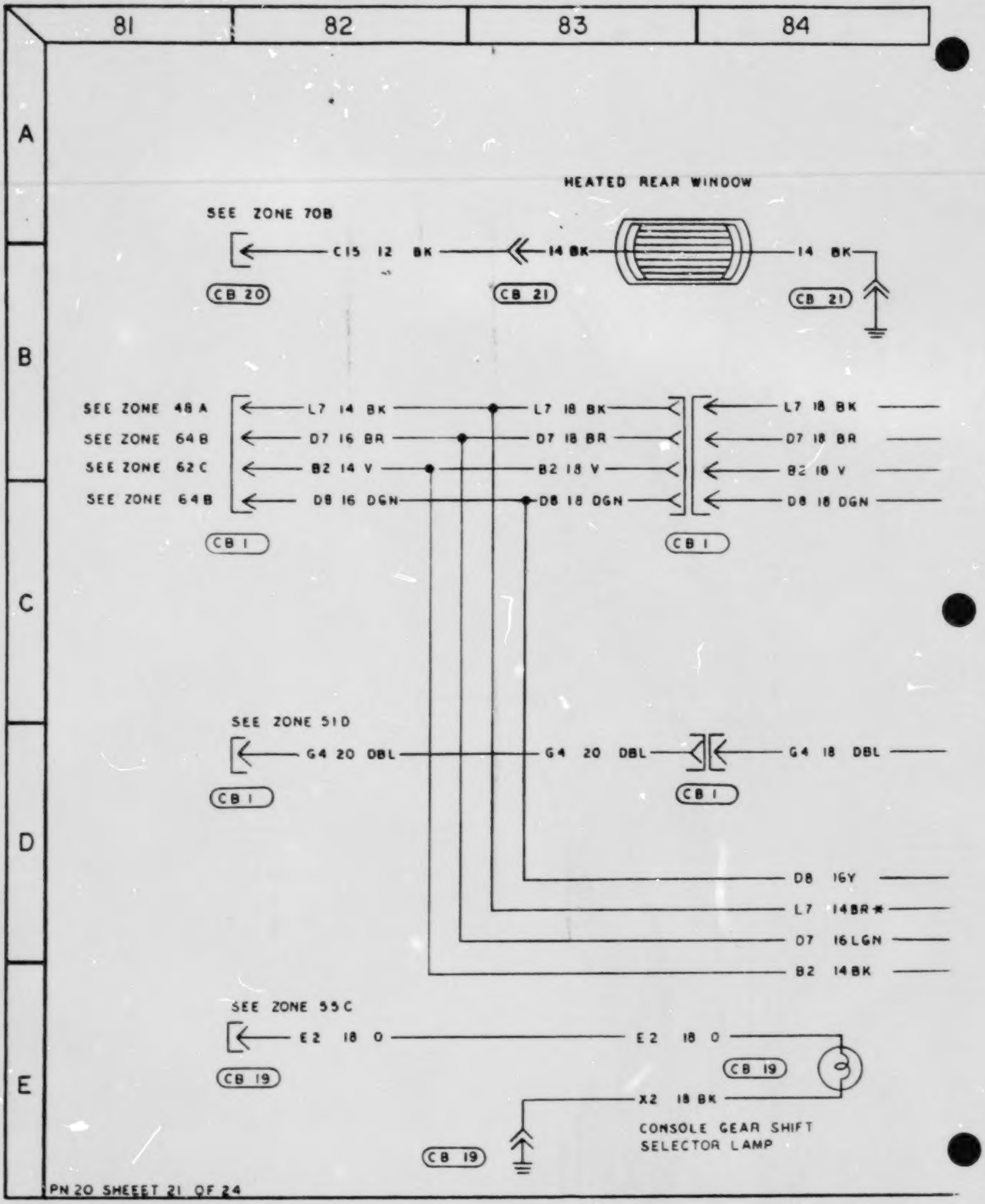

69
70
71
72
G5 20 DBL*
M2 20 Y
C1 14 BK*
C1 16 BK*
C1 16 BK*
C1 14 BK*
C1 44
C1 44
18 Y
HEATED REAR WINDOW INDICATOR LAMP
C15 12 BK/Y*
C15 12 BK
HEATED REAR WINDOW RELAY
TIMER
L
X
P
Y
C1 42
C1 42
C1 42
C20 20 V
C14 20 W
C3 12 BK*
G5 20 DBL*
M2 20 Y
C15 12 BK
CB 20
SEE ZONE 81-B
C1 31
C1 31
H
L
NORMAL
ON
NORMAL
HEATED REAR WINDOW SWITCH
ON
OFF
OFF
B
C1 31
CE 1
SEE ZONE 24-B
G5 20 DBL*
M2 20 Y
M2 20 Y
C1 3
C1 5
M2 20 Y
C1 5
C1 3
RIGHT FRONT DOOR SWITCH
M2 20 Y
M2 20 Y
M2 20 Y
CB 1
SEE ZONE 89-D
M2 20 Y
18 BK
18 DGN
18 DGN
FRONT SPEAKER
C1 34
CB 18
SEE ZONE 94-A
18 DGN
FADER SWITCH
18 BK
18 DGN
18 DGN
18 BK
18 BK
WITHOUT FADER SWITCH
C1 32
18 DGN
18 BK
C1 9
18 R
MONAURAL RADIO
18 O
C1 9
X12 18 R*
E2 20 O
C1 18 LGN
M2 20 Y
E2 20 O
M2 20 Y
V1 14 P
M2 20 Y
X12 18 R*
C1 18 LGN
V1 14 P

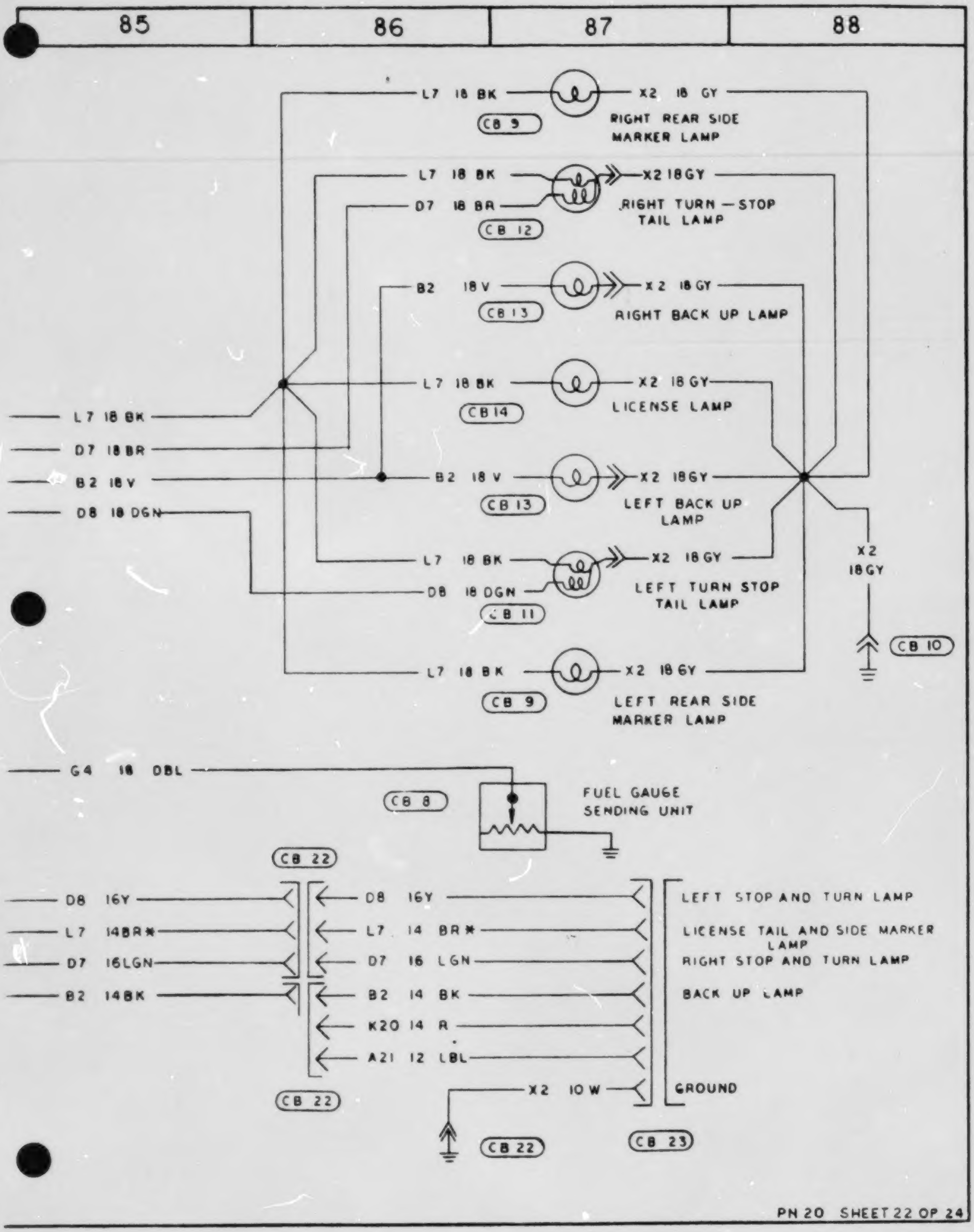
REVISED 10-75 PN20 SHEET 18 OF 24

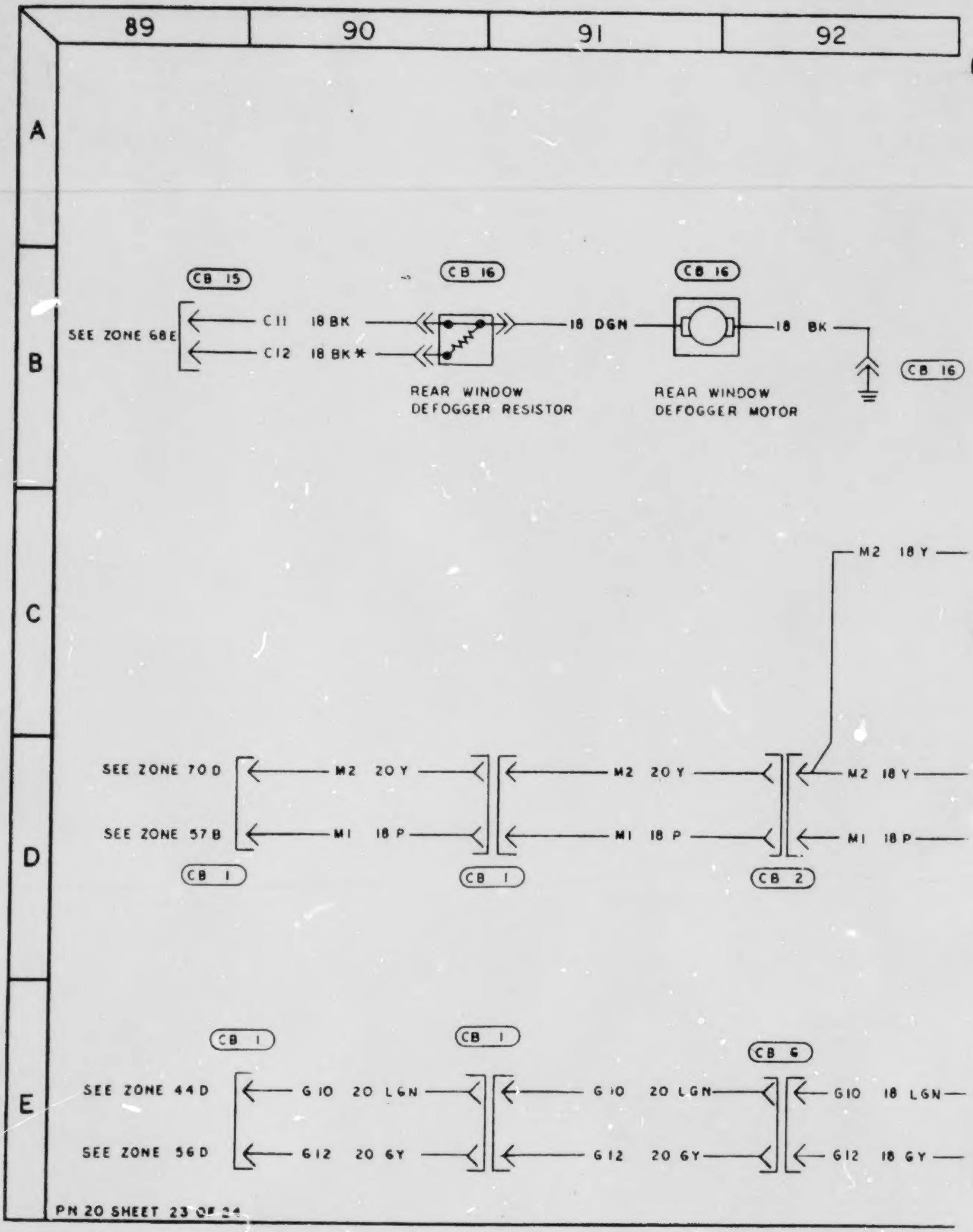

73
74
75
76
A
B
C
D
E
C1 16 BK ✱
C1 14 BK ✱
C1 16 BK ✱
C1 14 BK ✱
SEE ZONES 37C, 39C, 26A, 38C, 40C
CE 1
V6 18 DBL
V3 18 BR ✱
V4 18 R
V5 18 DGN
V10 20 BR
C1 11
(P) (A) (F1) (F2) (W)
P L H P L H
(B)
TWO SPEED WINDSHIELD WIPER SWITCH
SEE ZONES 37C, 39C, 26A, 38C, 40C
CE 1
V10 20 BR
V6 18 DBL
V3 18 BR ✱
V4 18 R
V5 18 DGN
C1 11
(W) (P) (A) (F1) (F2)
(B)
THREE SPEED WINDSHIELD WIPER SWITCH
C1 11
V1 14 P
C1 18 LGN
V1 14 P
C1 18 LGN
PN20 SHEET 19 OF 24

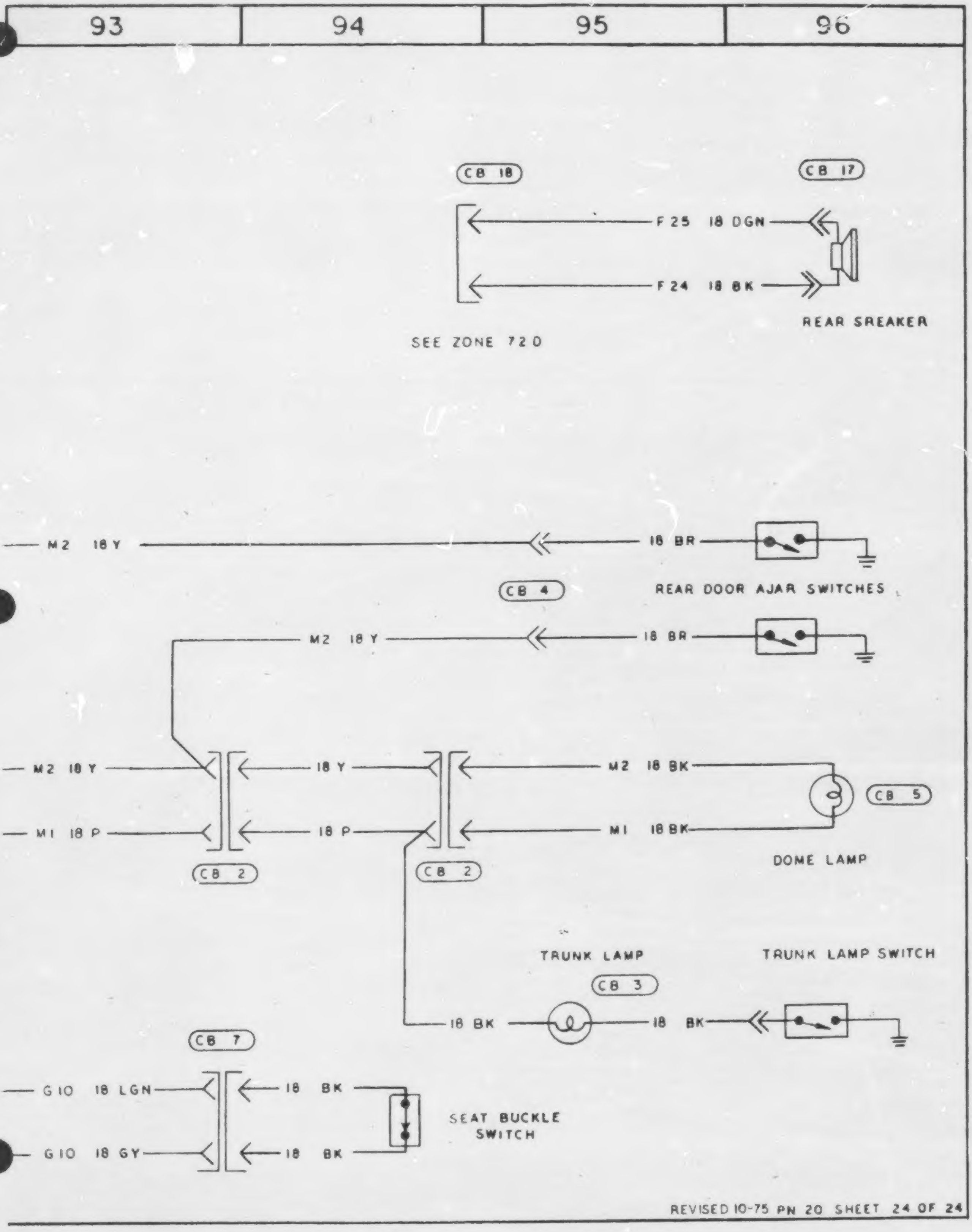

77
78
79
80
C1 16BK*
C1 14BK*
HEATER BLOWER MOTOR SWITCH
HEATER BLOWER MOTOR RESISTOR BLOCK
H
B
M
L
C1 16BK*
C5 16LGN
C4 16DGN
C3 18BR
C1 37
C1 29
HEATER MOTOR
C1 14BK*
C1 18LGN
C1 12
AIR CONDITIONER & HEATER VACUUM SWITCH
DEF
MAX
HT
CLUTCH
A C
VENT
C1 12
C2 18DBL*
C7 14T
C4 16BR
CE 1
SEE ZONE 36A
C1 15
C7 14T
C7 16T
C1 14
BLOWER MOTOR SWITCH
H
M
L
AIR CONDITIONER & HEATER BLOWER MOTOR RESISTOR BLOCK
C1 15
C1 14
C6 16LGN
C5 16DGN
C1 18LGN
C5 14DGN
SEE ZONE 28A
CE 1

681


81
82
83
84
A
B
C
D
E
HEATED REAR WINDOW
SEE ZONE 70B
C15 12 BK
14 BK
14 BK
CB 20
CB 21
CB 21
SEE ZONE 48 A
SEE ZONE 64 B
SEE ZONE 62 C
SEE ZONE 64 B
L7 14 BK
D7 16 BR
B2 14 V
D8 16 DGN
L7 18 BK
D7 18 BR
B2 18 V
D8 18 DGN
L7 18 BK
D7 18 BR
B2 18 V
D8 18 DGN
CB 1
CB 1
SEE ZONE 51D
G4 20 DBL
G4 20 DBL
G4 18 DBL
CB 1
CB 1
D8 16Y
L7 14BR*
D7 16LGN
B2 14BK
SEE ZONE 55C
E2 18 O
E2 18 O
CB 19
CB 19
X2 18 BK
CONSOLE GEAR SHIFT
SELECTOR LAMP
CB 19
PN 20 SHEEET 21 OF 24


85
86
87
88
L7 18 BK
X2 18 GY
CB 9
RIGHT REAR SIDE MARKER LAMP
L7 18 BK
D7 18 BR
X2 18GY
RIGHT TURN — STOP TAIL LAMP
CB 12
B2 18 V
X 2 18 GY
CB 13
RIGHT BACK UP LAMP
L7 18 BK
X2 18 GY
CB14
LICENSE LAMP
L7 18 BK
D7 18 BR
B2 18 V
D8 18 DGN
B2 18 V
X2 18GY
CB 13
LEFT BACK UP LAMP
X2 18GY
L7 18 BK
D8 18 DGN
X2 18 GY
CB 11
LEFT TURN STOP TAIL LAMP
CB 10
L7 18 BK
X2 18 GY
CB 9
LEFT REAR SIDE MARKER LAMP
G4 18 DBL
CB 8
FUEL GAUGE SENDING UNIT
CB 22
D8 16Y
L7 14BR*
D7 16LGN
B2 14BK
D8 16Y
L7 14 BR*
D7 16 LGN
B2 14 BK
K20 14 R
A21 12 LBL
X2 10 W
LEFT STOP AND TURN LAMP
LICENSE TAIL AND SIDE MARKER LAMP
RIGHT STOP AND TURN LAMP
BACK UP LAMP
GROUND
CB 22
CB 22
CB 23
PN 20 SHEET 22 OF 24


89
90
91
92
A
B
C
D
E
CB 15
CB 16
CB 16
SEE ZONE 68E
C11 18 BK
C12 18 BK*
18 DGN
18 BK
CB 16
REAR WINDOW DEFOGGER RESISTOR
REAR WINDOW DEFOGGER MOTOR
M2 18 Y
SEE ZONE 70 D
SEE ZONE 57 B
M2 20 Y
M1 18 P
M2 20 Y
M1 18 P
M2 18 Y
M1 18 P
CB 1
CB 1
CB 2
CB 1
CB 1
CB 6
SEE ZONE 44 D
SEE ZONE 56 D
G10 20 LGN
G12 20 GY
G10 20 LGN
G12 20 GY
G10 18 LGN
G12 18 GY


93
94
95
96
CB 18
CB 17
F 25 18 DGN
F 24 18 BK
REAR SREAKER
SEE ZONE 72 D
M2 18 Y
18 BR
REAR DOOR AJAR SWITCHES
CB 4
M2 18 Y
18 BR
M2 18 Y
18 Y
M2 18 BK
CB 5
M1 18 P
18 P
M1 18 BK
CB 2
CB 2
DOME LAMP
TRUNK LAMP
TRUNK LAMP SWITCH
CB 3
18 BK
18 BK
CB 7
G10 18 LGN
18 BK
SEAT BUCKLE SWITCH
G10 18 GY
18 BK

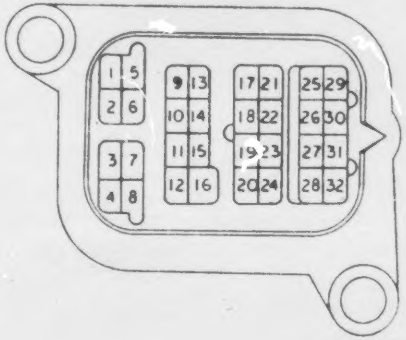
REVISED 10-75 PN 20 SHEET 24 OF 24

ENGINE COMPARTMENT

CE 1

ENGINE COMPARTMENT ZONE	CIRCUIT	CAVITY	INSTRUMENT PANEL CIRCUIT	ZONE
▲ 37-C OR ● 39-C	V3 18BR	1	V3 18BR*	▲ 73-C OR ● 74-C
▲ 38-C OR ● 40-C	V4 18R	2	V4 18R	▲ 74-C OR ● 75-C
——	——	3	——	——
◆ 32-B	B2 18V/BK*	4	B2 18W*	47-D
▲ 37-C OR ● 39-C	V6 18DBL	5	V6 18DBL	▲ 73-C OR ● 74-C
▲ 38-C OR ● 40-C	V5 18DGN	6	V5 18DGN	▲ 74-C OR ● 75-C
◆ 32-A OR ■ 30-A OR ⬢ 29-A	B2 18V/BK*	7	B2 18V/BK*	64-C
◆ 32-E OR ■ 30-D OR ⬢ 29-D	B1 18W	8	B1 18W	64-C
4-C	L4 18V*	9	L4 18V*	48-E
5-C	L6 18BK/Y*	10	L6 20BK/Y*	48-B
4-B	D5 18BK/T*	11	D5 18BK/T*	64-B
23-C	R16 20BK*	12	R16 20BK*	55-A
4-D	D6 18BK/LGN*	13	D6 18BK/LGN*	64-B
4-C	L3 18R	14	L3 18R/BK*	53-D
11-A	H2 16DGN/R*	15	H2 16DGN/R*	59-B
24-B	R6 12BK	16	R6 12BK	41-E
36-A	C2 18DBL	17	C2 18DBL*	79-C
——	——	18	——	——
26-A	V10 18BR	19	V10 20BR	▲ 73-C OR ● 74-C
20-B	A3 14P	20	A3 14P	57-A
36-B	P5 20BK	21	P5 20BK	50-D
27-D	S2 18Y	22	S2 14Y	41-E
——	——	23	——	——
28-A	C5 14DGN	24	C5 14DGN	79-D
24-C	J1 12R	25	J1 12R	41-E
15-A	J3 14BR	26	J3 14BR	41-E
15-D	J2 14DBL	27	J2 14DBL*	41-E
24-B	C13 12BK*	28	C13 12BK*	72-C
23-D	A11 20R*	29	A11 20R*	55-B
34-B	G2 20V	30	G2 20V	50-D
33-B	G6 20GY	31	G6 20GY	50-D
9-B	Y4 18LGN*	32	Y4 20LGN*	44-B

BULKHEAD DISCONNECT



▲ — TWO SPEED WINDSHIELD WIPERS
● — THREE SPEED WINDSHIELD WIPERS
◆ — MANUAL TRANSMISSION (4 SPEED)
■ — MANUAL TRANSMISSION (3 SPEED)
⬢ — AUTOMATIC TRANSMISSION

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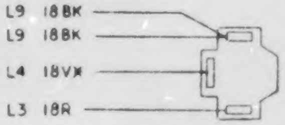
DASH PANEL-LEFT SIDE BELOW WINDSHIELD WIPER MOTOR

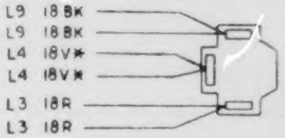
ENGINE COMPARTMENT

(CE 2) RIGHT HEADLIGHT


L9 18BK
L9 18BK
L4 18V*
L3 18R

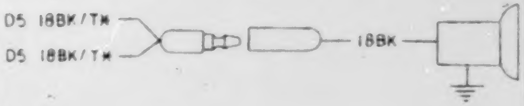
RIGHT FRONT FENDER

(CE 3) LEFT HEADLIGHT


L9 18BK
L9 18BK
L4 18V*
L4 18V*
L3 18R
L3 18R

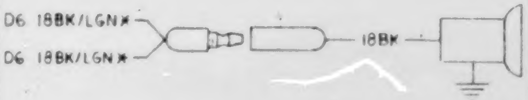
LEFT FRONT FENDER

(CE 4) RIGHT FRONT FENDER TOP TURN SIGNAL LAMP CONNECTOR


D5 18BK/T*
D5 18BK/T*
18BK

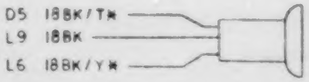
BELOW RIGHT HEADLIGHT

(CE 5) LEFT FRONT FENDER TOP TURN SIGNAL LAMP CONNECTOR


D6 18BK/LGN*
D6 18BK/LGN*
18BK

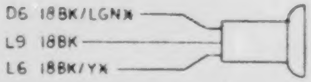
BELOW LEFT HEADLIGHT

(CE 6) RIGHT FRONT PARK AND TURN SIGNAL LAMP SOCKET


D5 18BK/T*
L9 18BK
L6 18BK/Y*

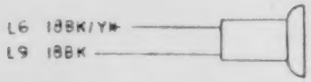
RIGHT SIDE OF GRILL

(CE 7) LEFT FRONT PARK AND TURN SIGNAL LAMP SOCKET


D6 18BK/LGN*
L9 18BK
L6 18BK/Y*

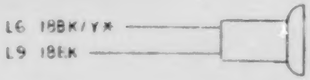
LEFT SIDE OF GRILL

(CE 8) RIGHT FRONT SIDE MARKER LAMP SOCKET


L6 18BK/Y*
L9 18BK

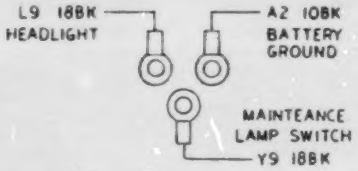
LOWER RIGHT FENDER

(CE 9) LEFT FRONT SIDE MARKER LAMP SOCKET


L6 18BK/Y*
L9 18BK

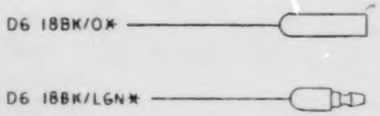
LOWER LEFT FENDER

(CE 10) HEADLIGHT, MAINTENANCE LAMP SWITCH, AND BATTERY GROUND


L9 18BK
HEADLIGHT
A2 10BK
BATTERY
GROUND
MAINTEANCE
LAMP SWITCH
Y9 18BK

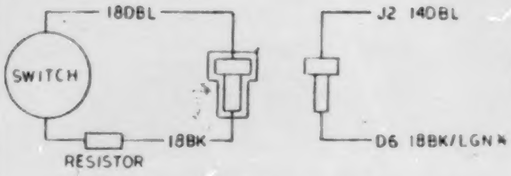
LEFT FRONT RADIATOR YOKE REINFORCEMENT

(CE 11) FUEL PACER FENDER TOP TURN SIGNAL CONNECTORS


D6 18BK/O*
D6 18BK/LGN*

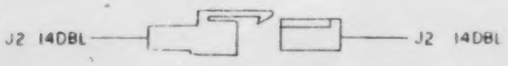
BELOW LEFT HEADLIGHT

(CE 12) FUEL PACER VACUUM SWITCH


18DBL
SWITCH
RESISTOR
18BK
J2 14DBL
D6 18BK/LGN*

FRONT LEFT FENDER SHIELD

(CE 13) FUEL PACER FEED IN-LINE CONNECTOR

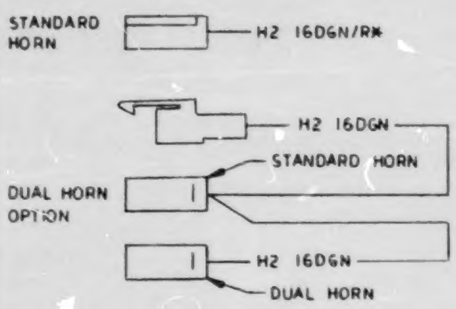

J2 14DBL
J2 14DBL

UNDER WINDSHIELD WASHER BOTTLE

PN 21 SHEET 2 OF 13

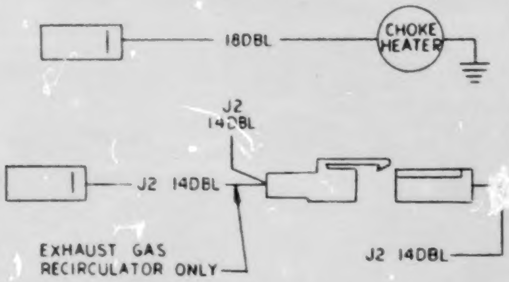
ENGINE COMPARTMENT

CE 14 HORNS


STANDARD HORN
H2 16DGN/R*
H2 16DGN
STANDARD HORN
DUAL HORN OPTION
H2 16DGN
DUAL HORN

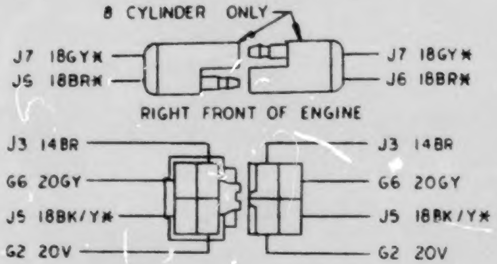
LEFT RADIATOR YOKE SIDE PANEL

CE 18 ELECTRIC CHOKE CONTROL CONNECTORS


18DBL
CHOKE HEATER
J2 14DBL
J2 14DBL
EXHAUST GAS RECIRCULATOR ONLY
J2 14DBL

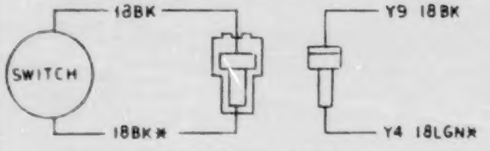
RIGHT REAR ENGINE

CE 21 ENGINE TO DASH IN-LINE CONNECTORS


8 CYLINDER ONLY
J7 18GY*
J5 18BR*
J7 18GY*
J6 18BR*
RIGHT FRONT OF ENGINE
J3 14BR
G6 20GY
J5 18BK/Y*
G2 20V
J3 14BR
G6 20GY
J5 18BK/Y*
G2 20V

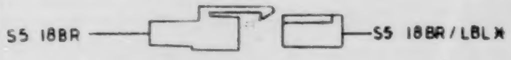
BETWEEN CENTER AND REAR CLIP OF RIGHT VALVE COVER

CE 15 EXHAUST GAS RECIRCULATOR MAINTENANCE LAMP SWITCH


18BK
SWITCH
18BK*
Y9 18BK
Y4 18LGN*

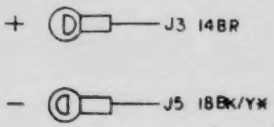
SPEEDOMETER CABLE

CE 19 EXHAUST GAS RECIRCULATOR IN-LINE CONNECTOR


S5 18BR
S5 18BR/LBL*

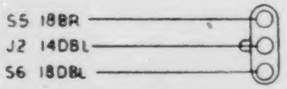
RIGHT SIDE DASH PANEL

CE 22 IGNITION COIL


+
J3 14BR
-
J5 18BK/Y*

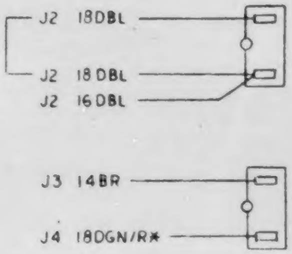
6 CYLINDER-RIGHT LOWER FRONT OF ENGINE
8 CYLINDER-CENTER REAR OF ENGINE

CE 16 EXHAUST GAS RECIRCULATOR VACUUM TIMER


S5 18BR
J2 14DBL
S6 18DBL

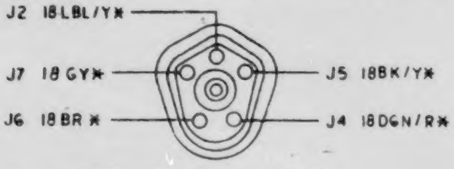
RIGHT SIDE DASH PANEL

CE 20 IGNITION BALLAST RESISTORS


J2 18DBL
J2 18DBL
J2 16DBL
J3 14BR
J4 18DGN/R*

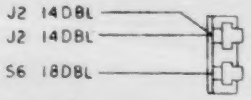
LEFT SIDE DASH PANEL

CE 23 ELECTRONIC IGNITION CONTROL


J2 18LBL/Y*
J7 18GY*
J6 18BR*
J5 18BK/Y*
J4 18DGN/R*

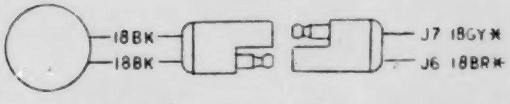
LEFT REAR FENDER SHIELD

CE 17 EXHAUST GAS RECIRCULATOR VACUUM SOLENOID


J2 14DBL
J2 14DBL
S6 18DBL

RIGHT REAR ENGINE

CE 24 DISTRIBUTOR CONNECTOR

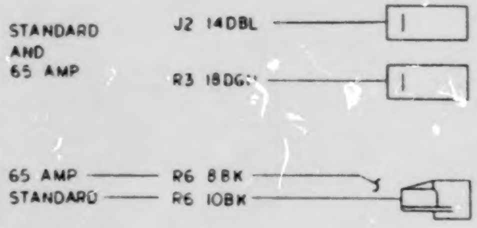

18BK
18BK
J7 18GY*
J6 18BR*

6 CYLINDER-RIGHT LOWER FRONT OF ENGINE
8 CYLINDER-CENTER REAR OF ENGINE

PN 21 SHEET 3 OF 13

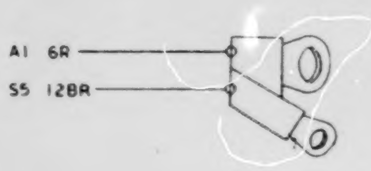
ENGINE COMPARTMENT

CE 25 ALTERNATOR


STANDARD AND 65 AMP
J2 14DBL
R3 18DGN
65 AMP
STANDARD
R6 8BK
R6 10BK

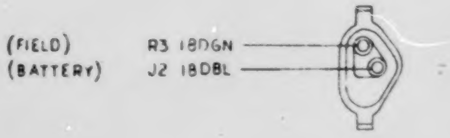
RIGHT FRONT ENGINE

CE 26 STARTER MOTOR


A1 6R
S5 12BR

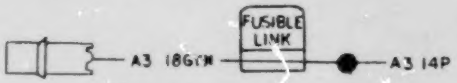
LEFT REAR LOWER ENGINE

CE 27 ELECTRONIC VOLTAGE REGULATOR

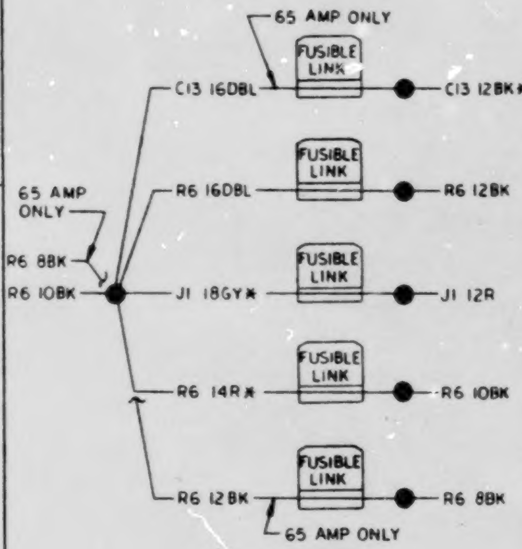

(FIELD)
(BATTERY)
R3 18DGN
J2 18DBL

RIGHT REAR FENDER SIDE SHIELD

CE 28 FUSIBLE LINKS

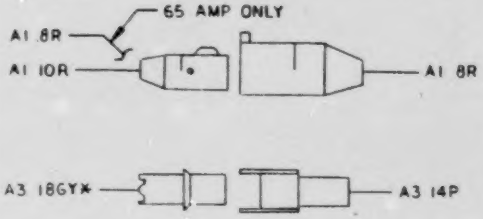

FUSIBLE LINK
A3 18GY*
A3 14P

LEFT CENTER FENDER SIDE SHIELD


65 AMP ONLY
FUSIBLE LINK
C13 16DBL
C13 12BK*
R6 16DBL
R6 12BK
65 AMP ONLY
R6 8BK
R6 10BK
J1 18GY*
J1 12R
R6 14R*
R6 10BK
R6 12BK
R6 8BK
65 AMP ONLY

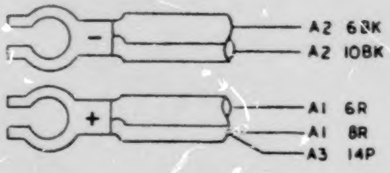
LEFT DASH PANEL

CE 29 BATTERY IN-LINE CONNECTION


65 AMP ONLY
A1 8R
A1 10R
A1 8R
A3 18GY*
A3 14P

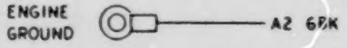
LEFT CENTER SIDE SHIELD

CE 30 BATTERY


-
+
A2 6BK
A2 10BK
A1 6R
A1 8R
A3 14P

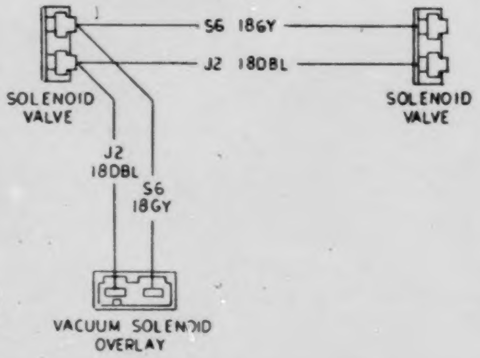
LEFT FRONT SIDE SHIELD

CE 31 ENGINE BATTERY GROUND


ENGINE GROUND
A2 6BK

ENGINE BLOCK–FRONT LEFT SIDE

CE 32 EXHAUST GAS RECIRCULATOR VACUUM SOLENOID JUMPER

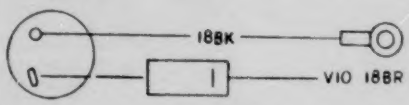

S6 18GY
J2 18DBL
SOLENOID VALVE
SOLENOID VALVE
J2 18DBL
S6 18GY
VACUUM SOLENOID OVERLAY

RIGHT REAR ENGINE

PN 21 SHEET 4 OF 13

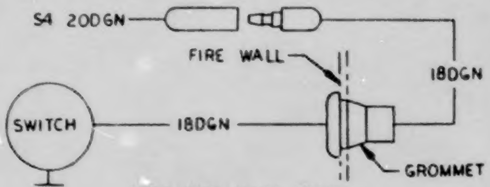
ENGINE COMPARTMENT

CE 33 ELECTRIC WINDSHIELD WASHER PUMP MOTOR


18BK
VIO 18BR

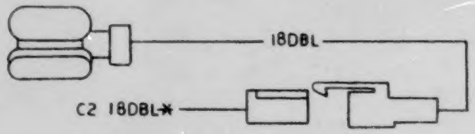
BELOW WINDSHIELD WASHER TANK

CE 36 MANUAL TRANSMISSION CLUTCH START SWITCH CONNECTOR


S4 20DGN
FIRE WALL
18DGN
SWITCH
18DGN
GROMMET

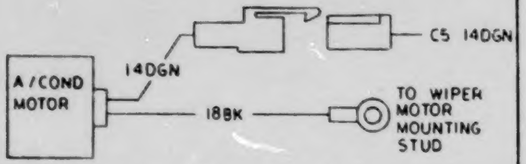
LEFT SIDE DASH PANEL

CE 40 AIR CONDITIONER COMPRESSOR CLUTCH


18DBL
C2 18DBL*

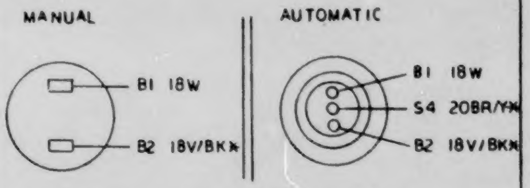
FRONT CENTER ENGINE

CE 34 AIR CONDITIONER BLOWER MOTOR CONNECTOR


C5 14DGN
14DGN
A/COND MOTOR
18BK
TO WIPER MOTOR MOUNTING STUD

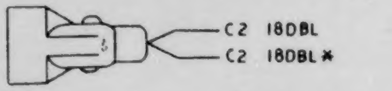
DASH PANEL RIGHT SIDE

CE 37 TRANSMISSION SWITCHES


MANUAL
B1 18W
B2 18V/BK*
AUTOMATIC
B1 18W
S4 20BR/Y*
B2 18V/BK*

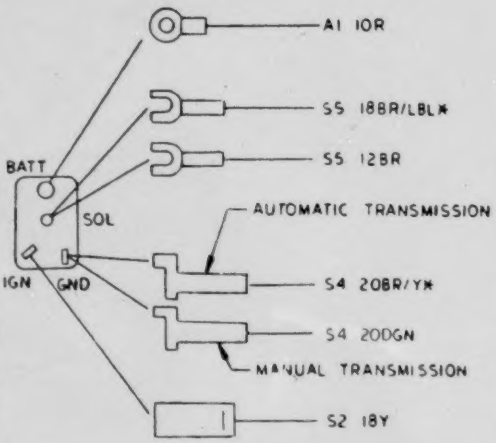
LOWER LEFT SIDE OF TRANSMISSION

CE 41 AIR CONDITIONER LOW PRESSURE SWITCH


C2 18DBL
C2 18DBL*

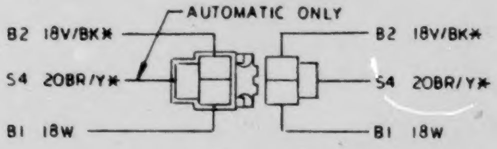
RIGHT FENDER SIDE SHIELD

CE 35 STARTER RELAY


A1 10R
S5 18BR/LBL*
S5 12BR
BATT
SOL
AUTOMATIC TRANSMISSION
IGN
GND
S4 20BR/Y*
S4 20DGN
MANUAL TRANSMISSION
S2 18Y

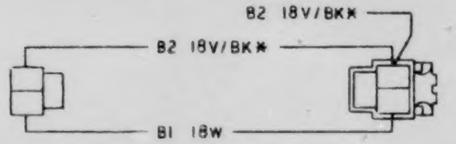
COWL TOP PANEL - LEFT SIDE

CE 38 TRANSMISSION IN-LINE CONNECTOR


AUTOMATIC ONLY
B2 18V/BK*
S4 20BR/Y*
B1 18W
B2 18V/BK*
S4 20BR/Y*
B1 18W

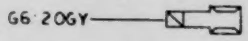
RIGHT REAR OF ENGINE

CE 39 REVERSE GEAR INDICATOR JUMPER
(4 SPEED ONLY)


B2 18V/BK*
B2 18V/BK*
B1 18W

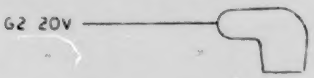
RIGHT REAR OF ENGINE

CE 42 LOW OIL PRESSURE SWITCH



6 CYLINDER - RIGHT SIDE OF ENGINE
8 CYLINDER - REAR OF ENGINE

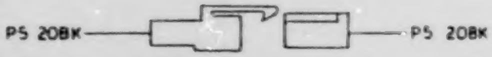
CE 43 TEMPERATURE GAUGE SENDING UNIT



RIGHT FRONT OF ENGINE

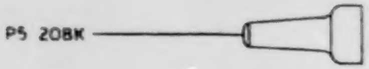
ENGINE COMPARTMENT

(CE 44) PLANT BRAKE TEST


P5 20BK
P5 20BK

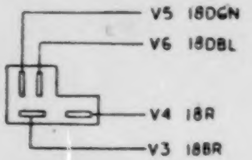
LEFT SIDE DASH PANEL

(CE 45) BRAKE WARNING LAMP SWITCH



LEFT LOWER REAR SIDE SHIELD

(CE 46) TWO SPEED WINDSHIELD WIPER MOTOR

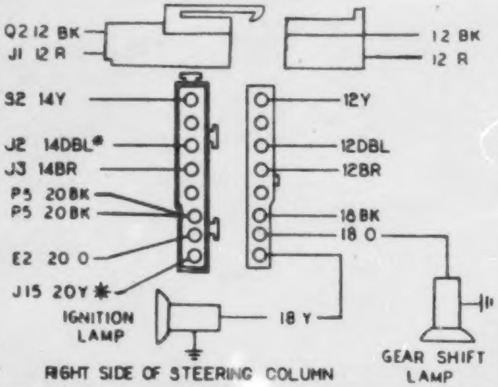

V5 18DGN
V6 18DBL
V4 18R
V3 18BR

CENTER COWL TOP PANEL

INSTRUMENT PANEL COMPARTMENT

CI 1

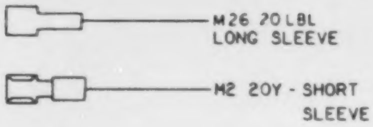
STARTER AND IGNITION SWITCH CONNECTOR


Q2 12 BK
J1 12 R
12 BK
12 R
S2 14Y
J2 14DBL*
J3 14BR
P5 20BK
P5 20BK
E2 20 0
J15 20Y ✱
IGNITION LAMP
12Y
12DBL
12BR
18BK
18 0
18 Y
GEAR SHIFT LAMP

RIGHT SIDE OF STEERING COLUMN

CI 2

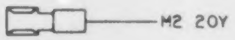
LEFT FRONT DOOR SWITCH


M26 20LBL
LONG SLEEVE
M2 20Y - SHORT SLEEVE

MIDDLE OF LEFT SIDE COWL

CI 3

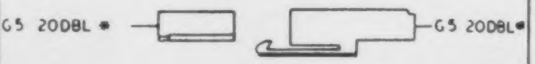
RIGHT FRONT DOOR SWITCH



MIDDLE OF RIGHT SIDE COWL

CI 4

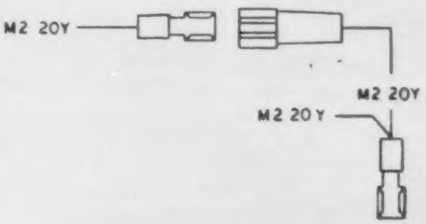
HEATED REAR WINDOW IGNITION FEED


G5 20DBL *
G5 20DBL*

LEFT OF FUSE BLOCK

CI 5

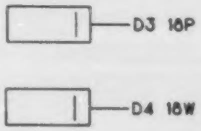
TAXI OPEN DOOR INDICATOR RIGHT FRONT DOOR SWITCH


M2 20Y
M2 20Y
M2 20 Y

MIDDLE OF RIGHT SIDE COWL

CI 6

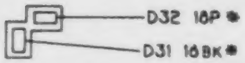
STOP LAMP SWITCH


D3 18P
D4 18W

BRAKE BRACKET RIGHT OF STEERING COLUMN

CI 7

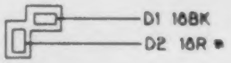
HAZARD FLASHER


D32 18P *
D31 18BK*

LEFT SIDE LOWER REINFORCEMENT

CI 8

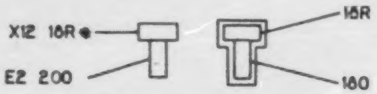
TURN SIGNAL FLASHER


D1 18BK
D2 18R *

LEFT SIDE LOWER REINFORCEMENT

CI 9

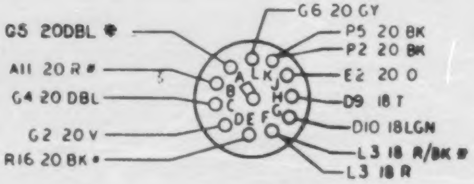
RADIO CONNECTOR


X12 18R *
E2 200
18R
180

LEFT SIDE RADIO

CI 10

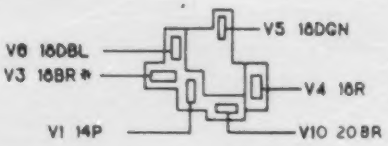
PRINTED CIRCUIT BOARD


G5 20DBL *
A11 20 R *
G4 20 DBL
G2 20 V
R16 20 BK *
G6 20 GY
P5 20 BK
P2 20 BK
E2 20 0
D9 18 T
D10 18LGN
L3 18 R/BK *
L3 18 R
A
B
C
D
E
F
G
H
J
K
L

RIGHT SIDE OF CLUSTER

CI 11

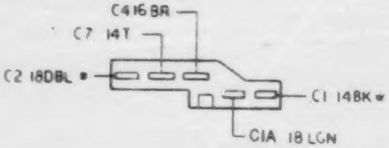
WINDSHIELD WIPER SWITCH


V6 18DBL
V3 18BR *
V1 14P
V5 18DGN
V4 18R
V10 20BR

LEFT OF RADIO

CI 12

AIR CONDITIONER AND HEATER VACUUM SWITCH

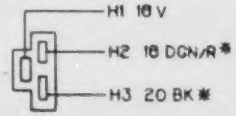

C4 16 BR
C7 14T
C2 18DBL *
C1 14BK *
C1A 18 LGN

ABOVE RADIO

INSTRUMENT PANEL COMPARTMENT

CI 13

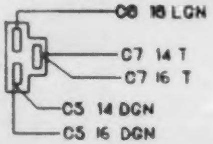
HORN RELAY


H1 18V
H2 18 DGN/R *
H3 20 BK *

ON GLOVE BOX LEFT SIDE

CI 14

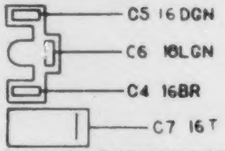
AIR CONDITIONER AND HEATER BLOWER MOTOR SWITCH


C8 18 LGN
C7 14 T
C7 16 T
C5 14 DGN
C5 16 DGN

ABOVE LEFT SIDE OF RADIO

CI 15

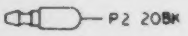
AIR CONDITIONER BLOWER MOTOR RESISTOR


C5 16 DGN
C6 18LGN
C4 16BR
C7 16T

RIGHT REAR FACE OF AIR CONDITIONER UNIT

CI 16

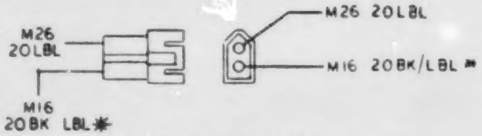
HAND BRAKE RELEASE SWITCH



LEFT OF STEERING COLUMN

CI 17

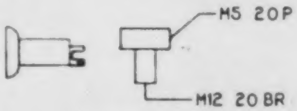
KEY-IN SWITCH CONNECTOR


M26 20LBL
M16 20BK LBL *
M26 20LBL
M16 20BK/LBL *

RIGHT OF STEERING COLUMN

CI 18

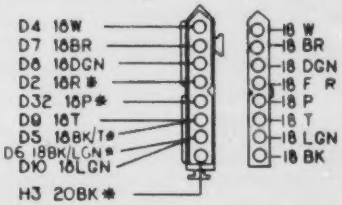
MAP LAMP


M5 20P
M12 20 BR

RIGHT SIDE LOWER REINFORCEMENT

CI 19

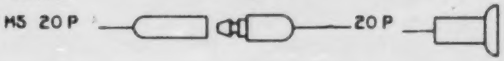
TURN SIGNAL SWITCH CONNECTOR


D4 18W
D7 18BR
D8 18DGN
D2 18R *
D32 18P *
D9 18T
D5 18BK/T *
D6 18BK/LGN *
D10 18LGN
H3 20BK *
18 W
18 BR
18 DGN
18 F R
18 P
18 T
18 LGN
18 BK

RIGHT OF STEERING COLUMN

CI 20

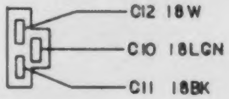
GLOVE BOX LAMP



RIGHT SIDE OF GLOVE BOX

CI 21

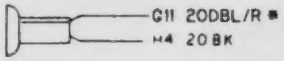
REAR WINDOW DEFOGGER SWITCH


C12 18W
C10 18LGN
C11 18BK

LEFT OF STEERING COLUMN

CI 22

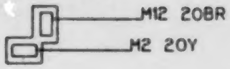
SEAT BELT LAMP


G11 20DBL/R *
H4 20BK

LEFT SIDE OF CLUSTER

CI 23

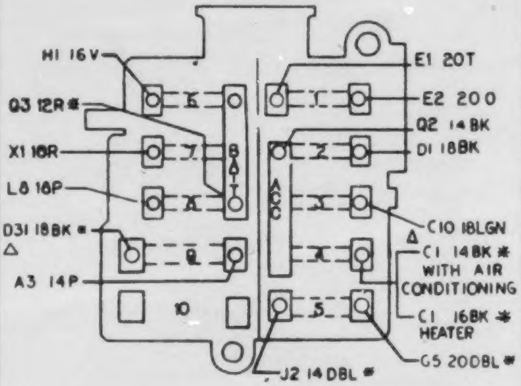
MAP LAMP SWITCH


M12 20BR
M2 20Y

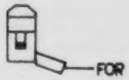
LEFT OF STEERING COLUMN

CI 24

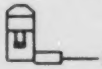
FUSE BLOCK


H1 16V
Q3 12R *
X1 18R
L8 18P
D31 18BK *
△
A3 14P
E1 20T
E2 20O
Q2 14BK
D1 18BK
C10 18LGN
△
C1 14BK * WITH AIR CONDITIONING
C1 16BK * HEATER
G5 20DBL *
J2 14DBL *
BAT
ACC
10

△ NOT PART OF MAIN HARNESS



FOR G5, L8, H1 E1, C1

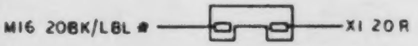


FOR J2, X1, E2, D1, C1

LEFT SIDE LOWER REINFORCEMENT

CI 25

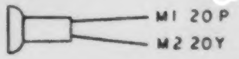
KEY-IN BUZZER


M16 20BK/LBL *
X1 20R

LEFT SIDE LOWER REINFORCEMENT

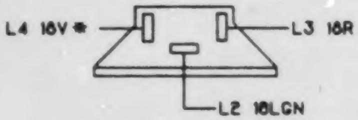
INSTRUMENT PANEL COMPARTMENT

CI 26 TAXI OPEN DOOR INDICATOR LAMP


M1 20 P
M2 20Y

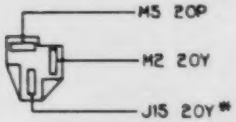
BENEATH RADIO

CI 27 FOOT DIMMER SWITCH


L4 18V *
L3 18R
L2 18LGN

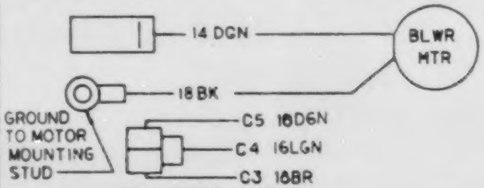
LEFT FRONT FLOOR

CI 28 TIME DELAY RELAY


M5 20P
M2 20Y
J15 20Y *

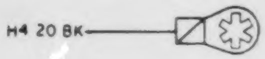
RIGHT OF STEERING COLUMN

CI 29 HEATER BLOWER MOTOR TO RESISTOR CONNECTOR


14 DGN
BLWR MTR
18 BK
GROUND TO MOTOR MOUNTING STUD
C5 18DGN
C4 16LGN
C3 18BR

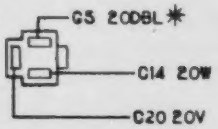
ON HEATER UNIT

CI 30 PANEL GROUND



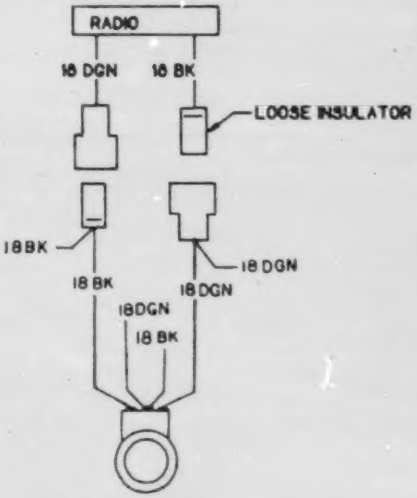
LOWER REINFORCEMENT RIGHT SIDE

CI 31 HEATED REAR WINDOW SWITCH


C5 20DBL *
C14 20W
C20 20V

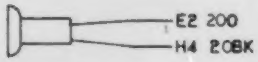
LEFT SIDE OF INSTRUMENT PANEL

CI 32 FADER SWITCH


RADIO
18 DGN
18 BK
LOOSE INSULATOR
18BK
18 BK
18 DGN
18DGN
18DGN
18 BK

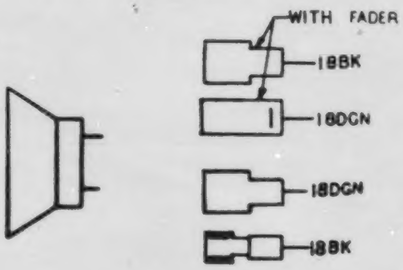
LEFT OF RADIO

CI 33 AIR CONDITIONER LAMP OR HEATER LAMP


E2 200
H4 20BK

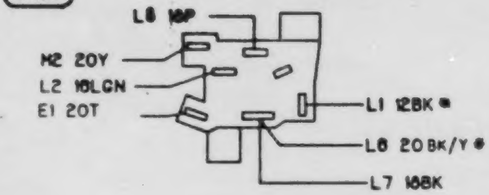
REAR OF AIR CONDITIONER VACUUM SWITCH

CI 34 FRONT SPEAKER


WITH FADER
18BK
18DGN
18DGN
18BK

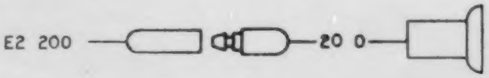
CENTER INSTRUMENT PANEL

CI 35 HEADLIGHT SWITCH


L6 18P
M2 20Y
L2 18LGN
E1 20T
L1 12BK *
L6 20 BK/Y *
L7 18BK

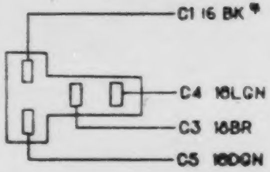
LEFT SIDE OF CLUSTER

CI 36 ASH TRAY LAMP CONNECTOR



REAR OF ASH RECEIVER HOUSING

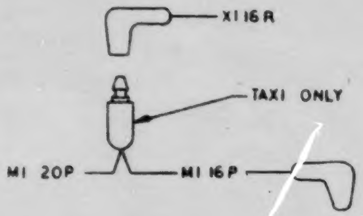
CI 37 HEATER BLOWER MOTOR SWITCH


C1 16 BK *
C4 18LGN
C3 18BR
C5 18DGN

CENTER REAR OF INSTRUMENT PANEL

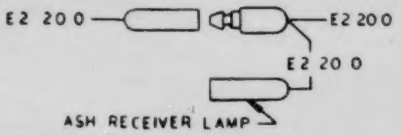
INSTRUMENT PANEL COMPARTMENT

C1 38 CIGARETTE LIGHTER


X1 16 R
TAXI ONLY
M1 20 P
M1 16 P

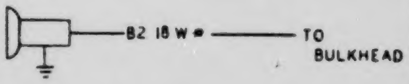
REAR OF ASH RECEIVER

C1 39 CONSOLE LAMP CONNECTOR


E2 20 O
E2 20 O
E2 20 O
ASH RECEIVER LAMP

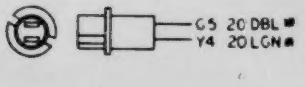
REAR OF ASH RECEIVER

C1 40 REVERSE GEAR INDICATOR LAMP


B2 18 W *
TO BULKHEAD

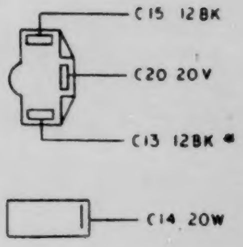
LEFT OF ASH RECEIVER

C1 41 EXHAUST GAS RECIRCULATION MAINTENANCE WARNING LAMP


G5 20 DBL *
Y4 20 LGN *

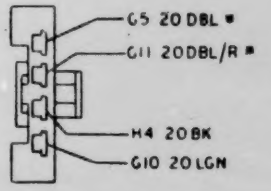
LEFT SIDE OF CLUSTER

C1 42 HEATED REAR WINDOW RELAY


C15 12 BK
C20 20 V
C13 12 BK *
C14 20 W

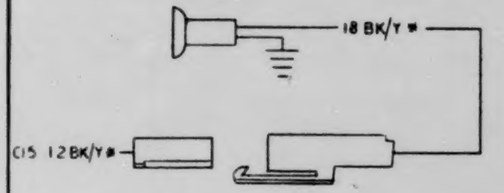
LEFT OF GLOVE BOX

C1 43 SEAT BELT BUZZER


G5 20 DBL *
G11 20 DBL/R *
H4 20 BK
G10 20 LGN

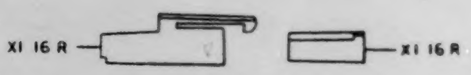
LEFT SIDE LOWER REINFORCEMENT

C1 44 HEATED REAR WINDOW INDICATOR LAMP AND CONNECTOR


18 BK/Y *
C15 12 BK/Y *

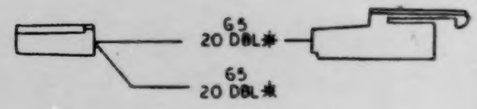
LEFT SIDE INSTRUMENT PANEL

C1 45 CIRCUIT X1 SPLICE CONNECTOR


X1 16 R
X1 16 R

ABOVE CLUSTER INSIDE HARNESS

C1 46 EXHAUST GAS RECIRCULATION CONNECTOR

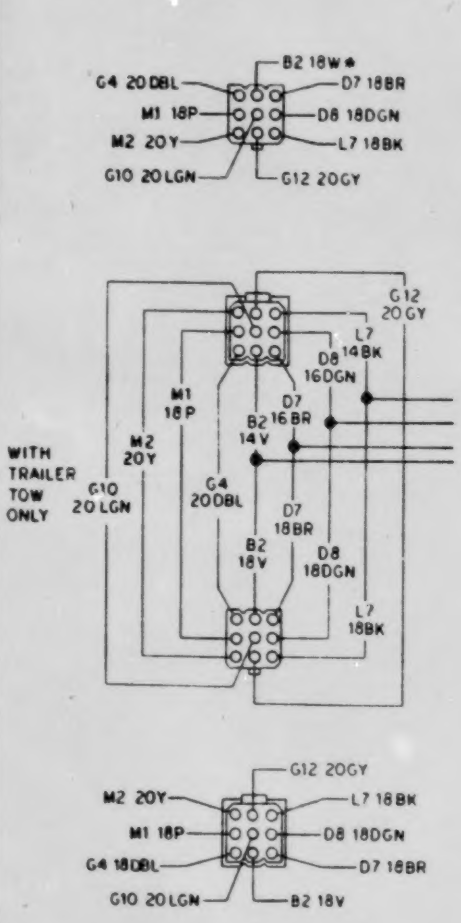

G5 20 DBL *
G5 20 DBL *

LEFT OF FUSE BLOCK

PN21 SHEET 10 OF 13

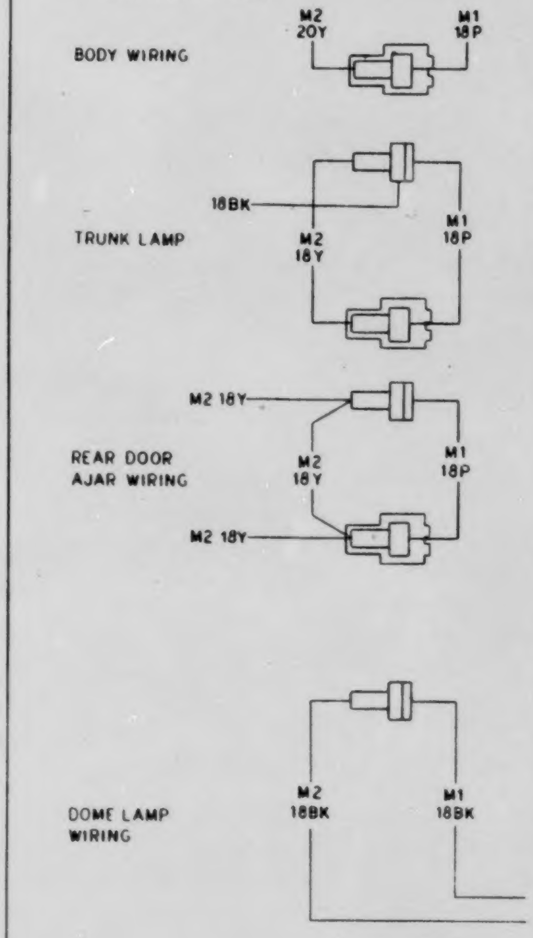
BODY COMPARTMENT

CB 1 INSTRUMENT PANEL TO BODY CONNECTOR


B2 18W*
G4 20DBL
D7 18BR
M1 18P
D8 18DGN
M2 20Y
L7 18BK
G10 20LGN
G12 20GY
G12 20GY
L7 14BK
D8 16DGN
D7 16BR
M1 18P
B2 14V
M2 20Y
WITH TRAILER TOW ONLY
G10 20LGN
G4 20DBL
D7 18BR
B2 18V
D8 18DGN
L7 18BK
G12 20GY
M2 20Y
L7 18BK
M1 18P
D8 18DGN
G4 18DBL
D7 18BR
G10 20LGN
B2 18V

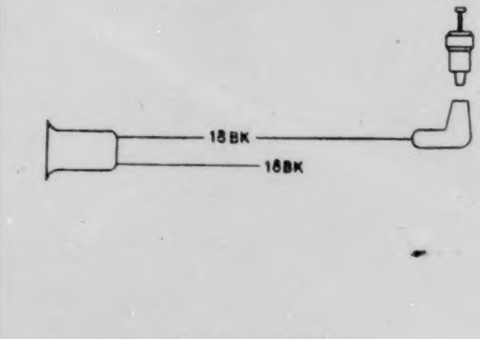
LEFT SIDE COWL

CB 2 BODY TO DOME LAMP CONNECTORS


BODY WIRING
M2 20Y
M1 18P
18BK
TRUNK LAMP
M2 18Y
M1 18P
M2 18Y
REAR DOOR AJAR WIRING
M2 18Y
M1 18P
M2 18Y
DOME LAMP WIRING
M2 18BK
M1 18BK

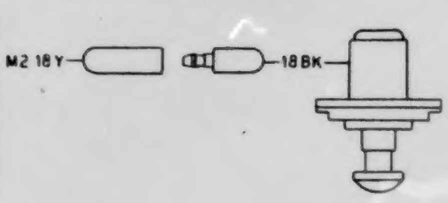
LEFT REAR WHEELHOUSE

CB 3 TRUNK LAMP AND SWITCH



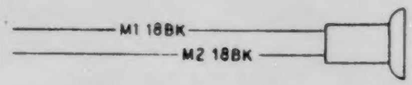
DECK LID OPENING

CB 4 REAR DOOR AJAR SWITCH CONNECTOR MODEL 41



LEFT AND RIGHT REAR DOOR LOCK PILLAR

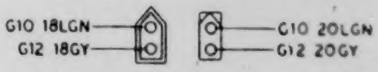
CB 5 DOME LAMP


M1 18BK
M2 18BK

CENTER ROOF

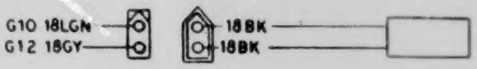
BODY COMPARTMENT

CB 6 SEAT BELT TO BODY WIRING CONNECTOR


G10 18LGN
G12 18GY
G10 20LGN
G12 20GY

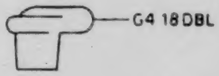
LEFT SIDE SILL

CB 7 SEAT BELT WIRING TO LEFT BUCKLE SWITCH CONNECTION


G10 18LGN
G12 18GY
18BK
18BK

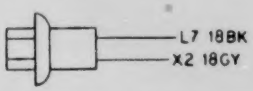
UNDER SEATS

CB 8 FUEL GAUGE SENDING UNIT



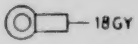
FRONT OF GAS TANK

CB 9 REAR SIDE MARKER LAMP


L7 18BK
X2 18GY

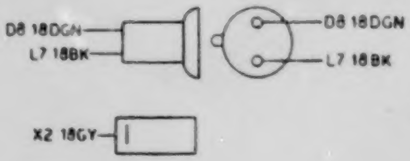
LEFT AND RIGHT LOWER QUARTER PANEL

CB 10 TAIL LAMP GROUND



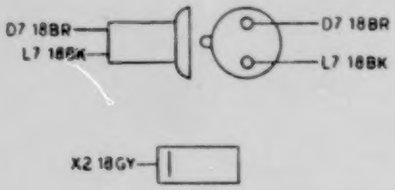
DECK LID AREA

CB 11 LEFT TURN STOP AND TAIL LAMP


D8 18DGN
L7 18BK
D8 18DGN
L7 18BK
X2 18GY

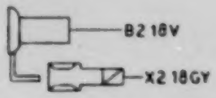
ABOVE REAR BUMPER

CB 12 RIGHT TURN STOP AND TAIL LAMP


D7 18BR
L7 18BK
D7 18BR
L7 18BK
X2 18GY

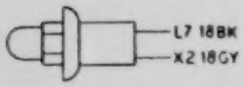
ABOVE REAR BUMPER

CB 13 BACK UP LAMP


B2 18V
X2 18GY

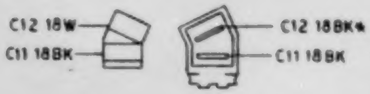
ABOVE REAR BUMPER

CB 14 LICENSE LAMP


L7 18BK
X2 18GY

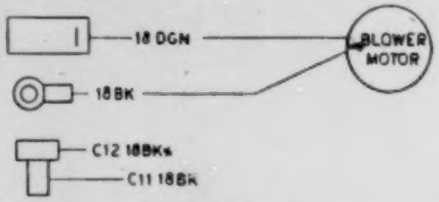
ABOVE LICENSE PLATE

CB 15 REAR WINDOW DEFOGGER MOTOR CONNECTOR


C12 18W
C11 18BK
C12 18BK*
C11 18BK

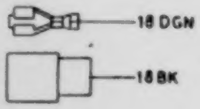
LEFT SIDE COWL

CB 16 REAR WINDOW DEFOGGER BLOWER MOTOR


18 DGN
BLOWER MOTOR
18BK
C12 18BK*
C11 18BK

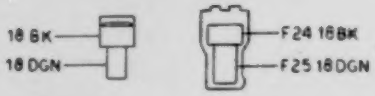
REAR SHELF PANEL

CB 17 REAR SPEAKER



LEFT REAR SHELF PANEL

CB 18 REAR SPEAKER BODY CONNECTOR

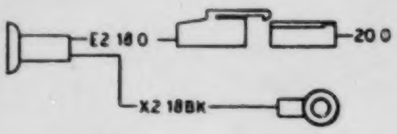

18 BK
18 DGN
F24 18BK
F25 18DGN

LOWER LEFT SIDE COWL

PN 21 SHEET 12 OF 13

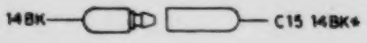
BODY COMPARTMENT

CB 19 CONSOLE LAMP


E2 18 O
20 O
X2 18BK

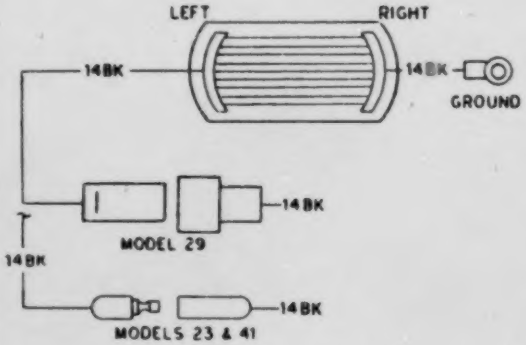
RIGHT SIDE COWL

CB 20 HEATED REAR WINDOW CONNECTOR


14BK
C15 14BK*

LEFT SIDE COWL

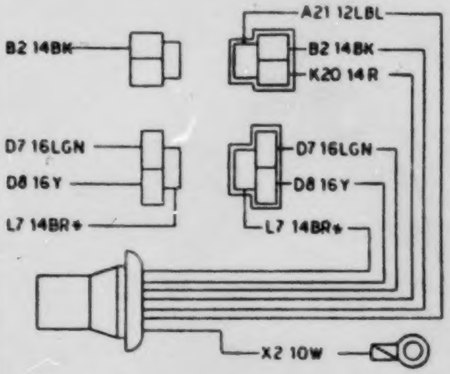
CB 21 HEATED REAR WINDOW


LEFT
RIGHT
14BK
14BK
GROUND
14BK
MODEL 29
14BK
14BK
MODELS 23 & 41

OVER LEFT REAR WHEELHOUSE

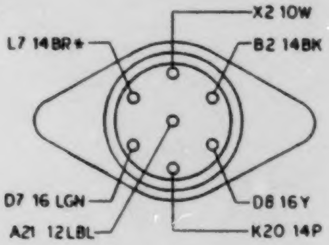
710

CB 22 TRAILER TOW BODY CONNECTOR


A21 12LBL
B2 14BK
B2 14BK
K20 14R
D7 16LGN
D8 16Y
L7 14BR*
D7 16LGN
D8 16Y
L7 14BR*
X2 10W

LEFT REAR OF CAR

CB 23 TRAILER TOW CONNECTOR


X2 10W
L7 14BR*
B2 14BK
D7 16 LGN
A21 12LBL
D8 16Y
K20 14P

REAR OF CAR

711

INTERIOR LIGHT BULBS

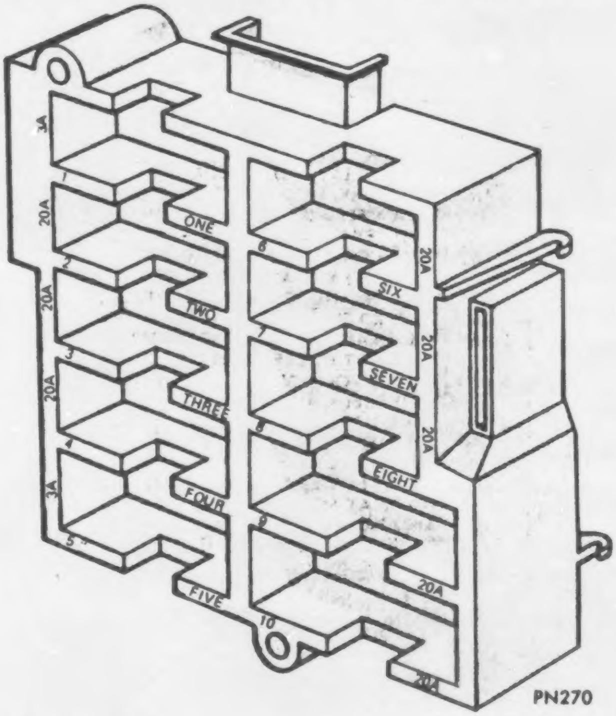
(C Models)

Headlight Switch, Rheostat Dimming	
Speedometer and Instrument Cluster	#158
Clock (Conventional)	#158
Clock (Digital)	#158
Heater, A/C or A.T.C.	#363
Radios all except	#168
Radio 8-Track Stereo Tape	#1816
Gear Selector	Note (A)
Headlight Switch	#1815
With Accessories Add	#161
Wiper/Washer Switch	#158
Rear Unlock Switch	Note (B)
Rear Window Switch	Note (B)
Rear Defrost Switch	#161
Antenna Switch	#161
Ash Tray	Note (C)
Cigar Lighter	#161
Right Ash Tray	#158
Door Ash Tray	#1892

Non-Dimming	
Brake Indicator	#158
High Beam Indicator	#158
Turn Signal Indicator	#158
Oil Indicator	#158
Ignition Lamp	#1445
Door Ajar	#158
Glove Compartment	#1891
Dome Lamp	#211-2
Map Lamp	#562
Trunk and/or Under Hood Lamp	#1003-1004
Fasten Belts	#158
Reading Lamp	#1004
Door Courtesy Lamp	#211-2
E.G.R. Maintenance Reminder Lamp	#158
Tailgate Ajar	#158
Heated Rear Window Switch	#74
Visor Vanity Lamp	#562
Stereo Indicator	#73

NOTE: (A) Included in instrument cluster lighting.
(B) Included in Wiper Switch Lighting.
(C) Included in Heater Control Lighting.
(D) All of the above bulbs are brass or wedge base. Aluminum base bulbs are not approved and not to be used.

CAVITY	FUSE	ITEMS FUSED
1.	3 AMP	INSTRUMENT CLUSTER, RADIO, GEAR SELECTOR, CONSOLE A/C CONTROL AND ASH TRAY LAMPS
2.	20 AMP	BACK-UP AND REVERSE GEAR INDICATOR LAMPS, TURN SIGNAL, RADIO AND A/C COMPRESSOR CLUTCH
3.	20 AMP	REAR WINDOW DEFOGGER AND SPEED CONTROL
4.	20 AMP	A/C OR HEATER BLOWER MOTOR
5.	3 AMP	VOLTAGE LIMITER, FUEL AND TEMP GAUGE; LOW OIL, DUAL BRAKE AND EGR LAMPS; HEATED REAR WINDOW COIL
6.	20 AMP	HORNS
7.	20 AMP	DOME, TRUNK, STOP, MAP, GLOVE BOX, IGNITION, SEAT BELT AND TRAILER STOP LAMPS; TIME DELAY RELAY, CIGARETTE LIGHTER AND SEAT BELT AND KEY-IN BUZZER
8.	20 AMP	TAIL, LICENSE, PARKING, SIDE MARKER AND TRAILER TAIL LAMPS; INSTRUMENT LAMPS (ALSO CAV ONE)
9.	20 AMP	HAZARD FLASHER
10.	20 AMP	VACANT



Fuses and Fuse Box (V-L Models)

X

Electrical Competencies - Body and Chassis

No. F-7 Interpret Wiring Diagrams

Worksheet #1

Name________________________ Date________________ Grade________________

Instructions: After being assigned a component by your instructor, use the Chrysler wiring diagram provided in information sheet #3 to trace the component's circuit from the component and its ground to its circuit protection device. In this chart provided, list components and codes, wire codes, connector codes and splice location (grid number) on the left hand side. On the right hand side, explain component and connector location wire designation codes and splice branch circuits. (see example)

Circuit: Backup lamps

Item	Location or Explanation
1. lamp socket CB 13	located above rear bumper
2. wire X2/18GY	circuit ground - 18 gauge - gray
3. splice (88-B)	joins all rear lighting grounds
4. connector CB10	ground eyelet - deck lid area
5. wire B2/18V	backup light circuit - 18 gauge - violet
6. connector CE1	bulkhead connector - cavity #8 dash panel - left side below windshield wiper motor
7. wire B1/18W	backup light circuit - 18 gauge - white
8. splice (61 - D)	joins wire B1/18W to X12/18R* (radio 71-E), D1/18BK (fuse panel, fuse #2, 59-D), C1/18LGN (air cond. clutch switch, 79-C), D1/18BK (turn signal flasher, 61-C)

Circuit:

Item	Location or Explaination

Electrical Compentencies - Body and Chasis

No. F-7 Interpret Wiring Diagrams

Worksheet #1
Page 2

Circuit:

Item	Location or Explanation

Instructor check ________

AUTO MECHANICS

Electrical Competencies - Body & Chassis

No. F-8 Identity Circuit Feedback

OBJECTIVE:

Upon completion of the following material, you will be able to recognize and trace common and uncommon feedback problems in automotive electrical circuits.

EXPLANATION:

Pass written test with ______% accuracy.

MATERIALS NEEDED:

Wiring Diagrams

TOOLS NEEDED:

References	Do
#1. p. 6-10 to 6-11	#1. Read the assigned references
#2. --	#2. Read information sheet #1
#3. p. 443-446	#3. Check with instructor
#4. p. 430-441	#4. Take Written test
#5. p. 522-526	#5. Check with instructor
#6. --	
#7. p. 221	
#8. p. 217-223	

No. F-8 Identify Circuit Feedback

Information Sheet #1

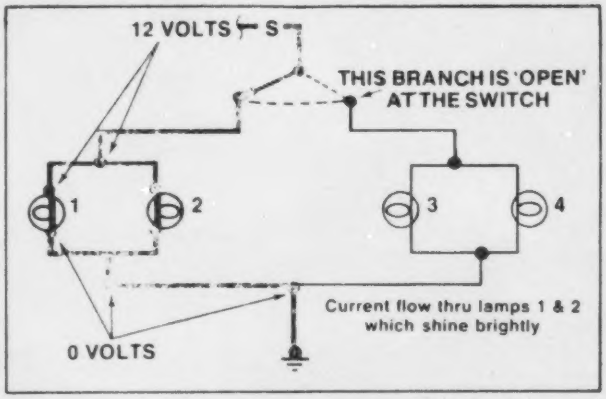
Cicuit Feedback

Circuit feedback is a condition resulting from a malfunction in the circuit. The apparent effect is the operation of certain lights and accessories without being activated in the normal manner.

The basic cause of a feedback problem is a circuit open. The open condition may occur on either the power side or the ground side of a circuit. One of the more common problems, and the easiest to recognize, is an open ground-feedback. The following discussion illustrates the problem.

Effects of Opens on Voltage and Current

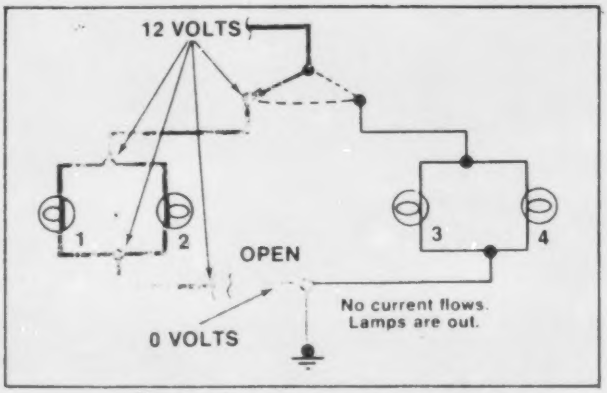
In a normally operating circuit such as the simple parallel circuit shown below, the left branch is receiving power; current flows through lamps 1 and 2; and, if tested with a voltmeter, the circuit would read 12 volts on the hot side and zero voltage on the ground side. Because the right branch of the parallel circuit is open at the switch, it is not powered.



Current flow thru lamps 1 & 2 which shine brightly

NORMALLY OPERATING SIMPLE PARALLEL CIRCUIT

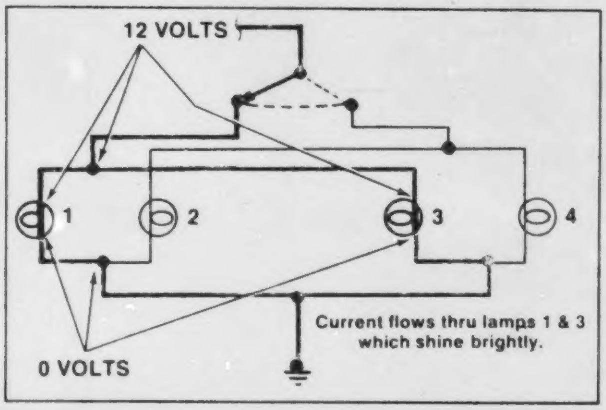
If an open occurs in the ground side of the powered branch, as shown below, the continuous path for electricity is broken, so no current flows. Voltage will be at 12 volts at all parts of the circuit between the power source and the open. The lesson to be learned from this example is that in a simple series or simple parallel circuit, when open, no current will flow and all points that are connected to the power source will be at source voltage.



No current flows. Lamps are out.

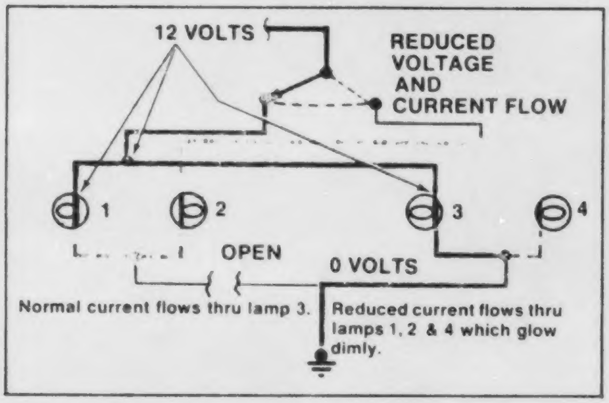
SIMPLE PARALLEL CIRCUIT WITH OPEN IN GROUND SIDE OF POWERED BRANCH

In more complex circuits, however, opens often have different affect on voltage and current. The figure below illustrates a variation of the circuit shown previously. When this circuit is operating normally, lamps 1 and 3 are powered when the switch is as shown. In this circuit, when an open occurs in the ground side of the powered branch, such as shown in the next figure, an alternate path to ground exists ghrough lamps 2 and 4. Lamps 1,2, and 4 then are in series, and all are in parallel with lamp 3. The higher resistance in the series branch of the circuit will cause lamps 1, 2, and 4 to glow dimly, while lamp 3, having less reisstance will glow brightly. Voltage reading will be 12 volts at both lamp 1 and lamp 3. In diagnosing for opens therefore, it is helpful to study the wiring diagrams for common points in the circuit and to look for alternate current paths.



Current flows thru lamps 1 & 3 which shine brightly.

NORMALLY OPERATING COMPLEX PARALLEL CIRCUIT



REDUCED VOLTAGE AND CURRENT FLOW

Normal current flows thru lamp 3.

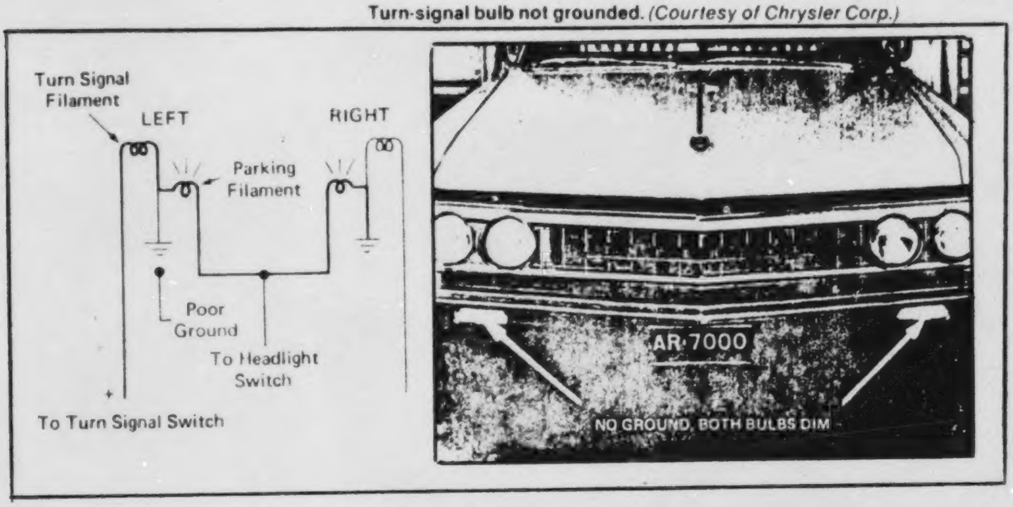
Reduced current flows thru lamps 1, 2 & 4 which glow dimly.

COMPLEX PARALLEL CIRCUIT BECOMES SERIES-PARALLEL CIRCUIT WITH OPEN IN GROUND SIDE OF POWERED BRANCH

Common Feedback Problems

The exact situation just described can occur in turn signal (front and rear), and head lamp circuits where more than one circuit share a direct ground splice wire. A commonly noticed condition occurs also on trailer lights which are not properly grounded to the tow vehicle.

Turn-signal bulb not grounded. *(Courtesy of Chrysler Corp.)*


Turn Signal Filament
LEFT
RIGHT
Parking Filament
Poor Ground
To Headlight Switch
+
To Turn Signal Switch
AR 7000
NO GROUND, BOTH BULBS DIM

Electrical Competencies- Body & Chassis

No. F-8 Identify Circuit Feedback

Information Sheet #2

Uncommon Feedback Problems

A more difficult to diagnose feedback condition occurs when the cause is an open in the power side of the circuit.

Let's examine a specific situation where the dome light, taillight, and stoplight fuse (a single fuse for all three) and the cigar lighter fuse are located in the main fuse block and connected to the same bus bar on the hot side (Fig. F8-1)

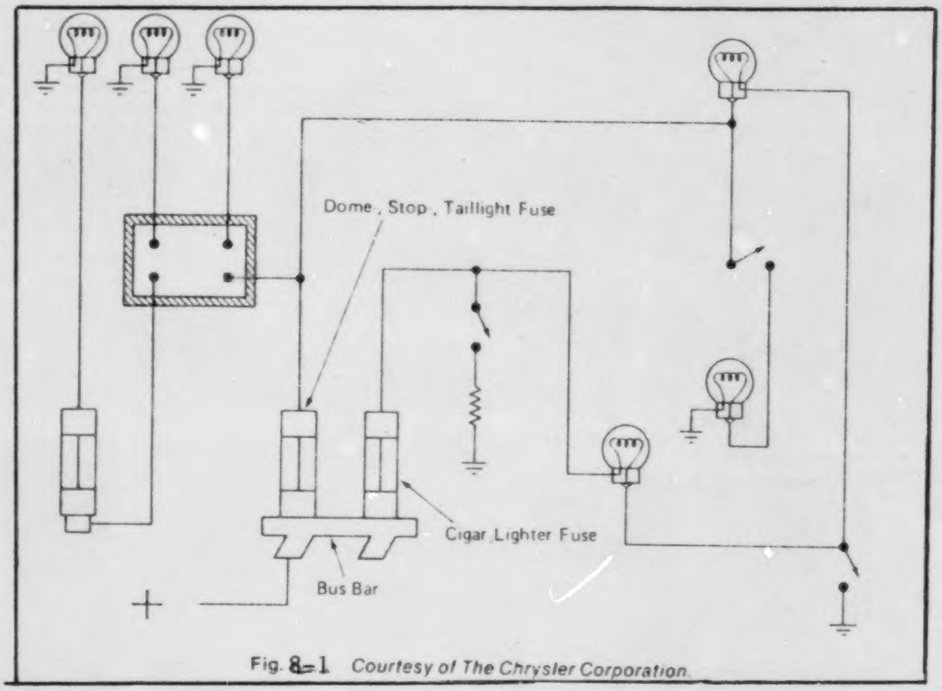
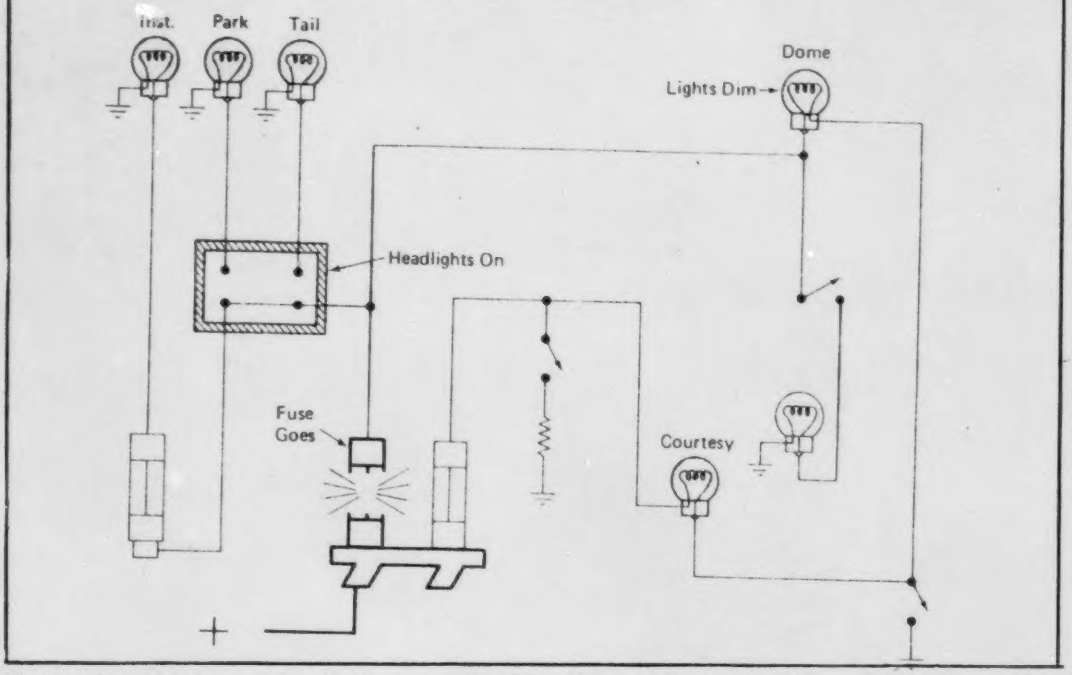


Fig. 8-1 *Courtesy of The Chrysler Corporation*

Blown dome light, taillight, and stop light fuse

When the headlight switch is turned on, Fig. F8-2, the courtesy light, dome light, taillight, parking lights, and instrument lights will be on but very dim. The current goes through the cigar lighter fuse to the courtesy light and on to the dome light switch in the door. The door switch is also connected to the dome light, so the current goes through the dome light and back to the headlight switch. Since the headlight switch is closed, the instrument panel lights are also in the circuit.

Fig. 8-2 *Courtesy of The Chrysler Corporation.*


Inst.
Park
Tail
Dome
Lights Dim
Headlights On
Fuse Goes
Courtesy
+

If the headlight switch is turned off, then all the lights will go out (Fig. F8-3) But with the headlight switch off and the car door open, the courtesy light will glow. The dome light will not light.

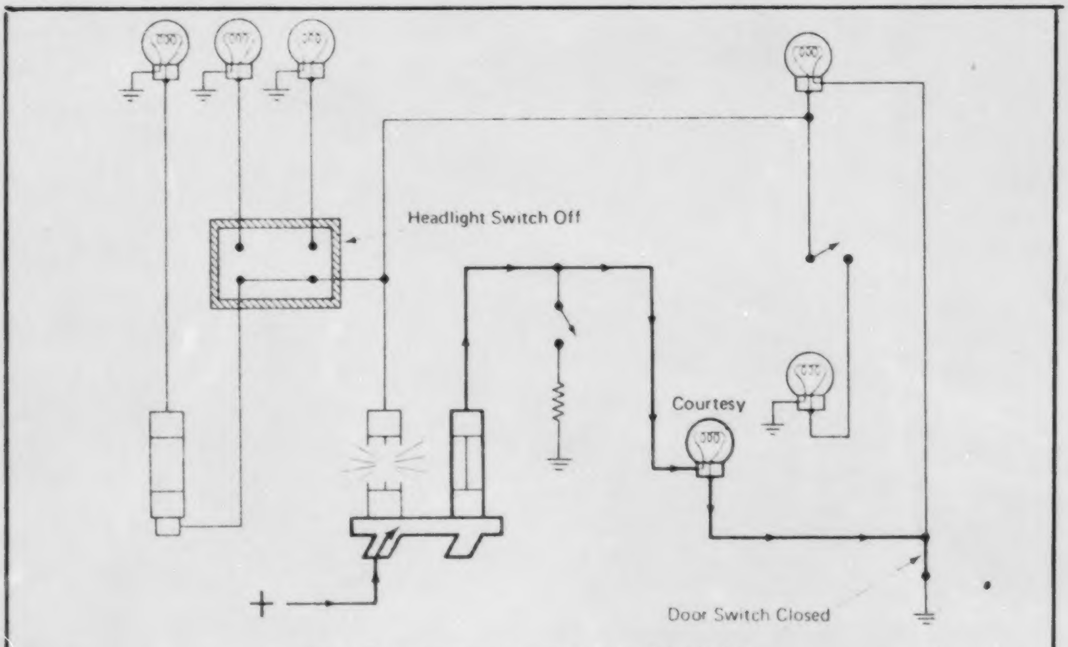

Headlight Switch Off
Courtesy
+
Door Switch Closed

Fig. 8-3 *Courtesy of The Chrysler Corporation.*

Another "crazy light" situation caused by the same blown fuse is illustrated in Fig. F8-4. Closing the stoplight switch will cause the dome light and courtesy light to turn on . But they will be very dim, because all the bulbs are in series.

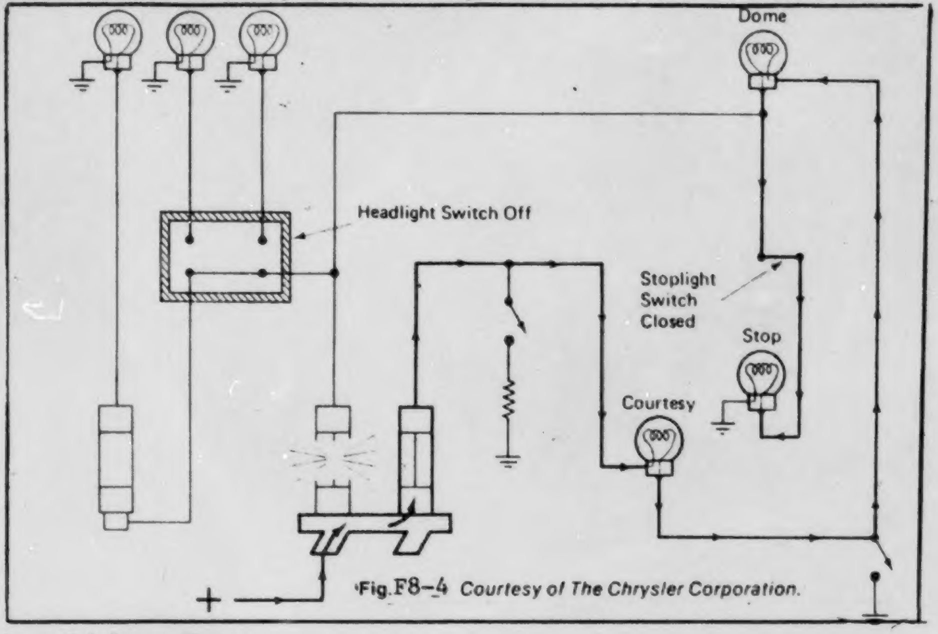
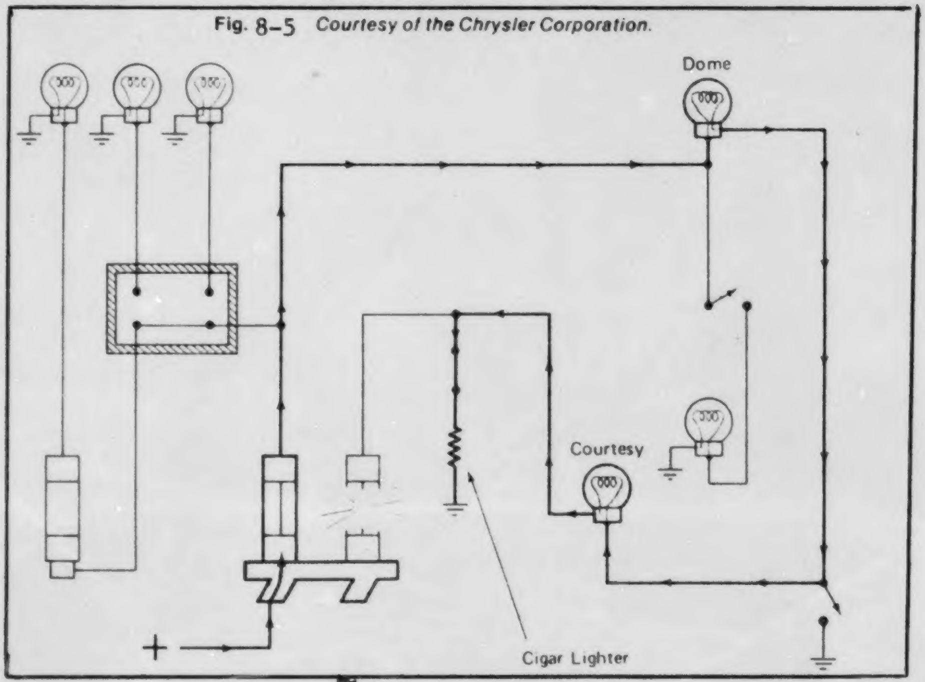

Dome
Headlight Switch Off
Stoplight Switch Closed
Stop
Courtesy
+

Fig.F8-4 *Courtesy of The Chrysler Corporation.*

Blown Cigar Lighter Fuse

Another feedback condition occurs when the cigar lighter fuse burns out (Fig. F8-5). The current to the dome light, stoplight, and taillight creates the feedback. If the cigar lighter is pushed in, current will flow through the dome light, stoplight, and taillight fuse to the dome light, door switch, and courtesy light, and through the lighter to ground. The lights will be on, but dim.

Fig. 8-5 *Courtesy of the Chrysler Corporation.*


Dome
Courtesy
+
Cigar Lighter

If the lighter is left pushed in, the battery will run down. There will not be enough voltage available to heat and release the lighter (Fig. F8-6).

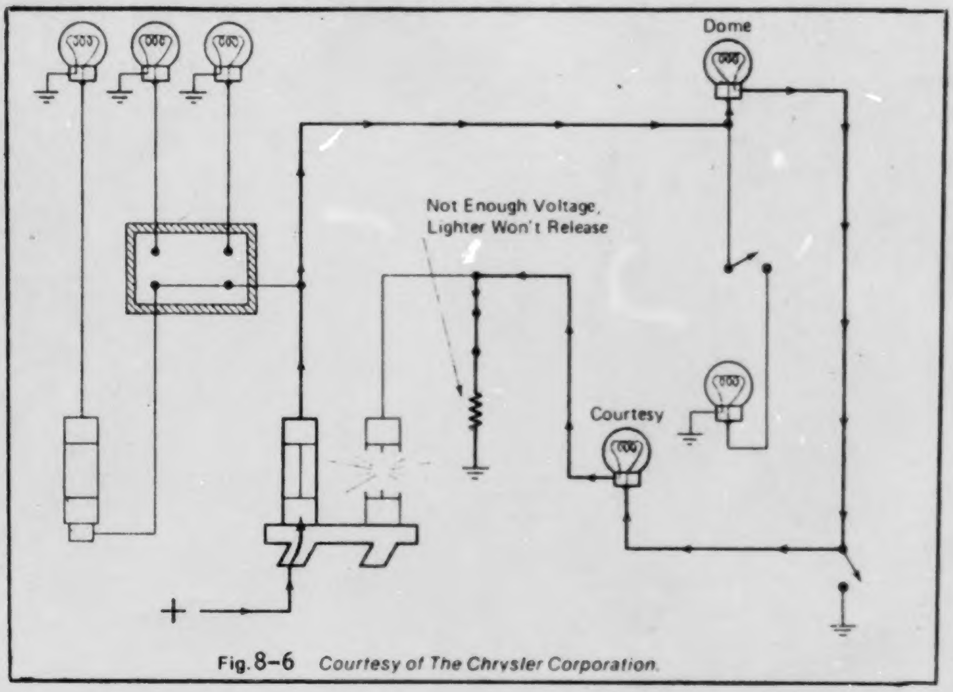
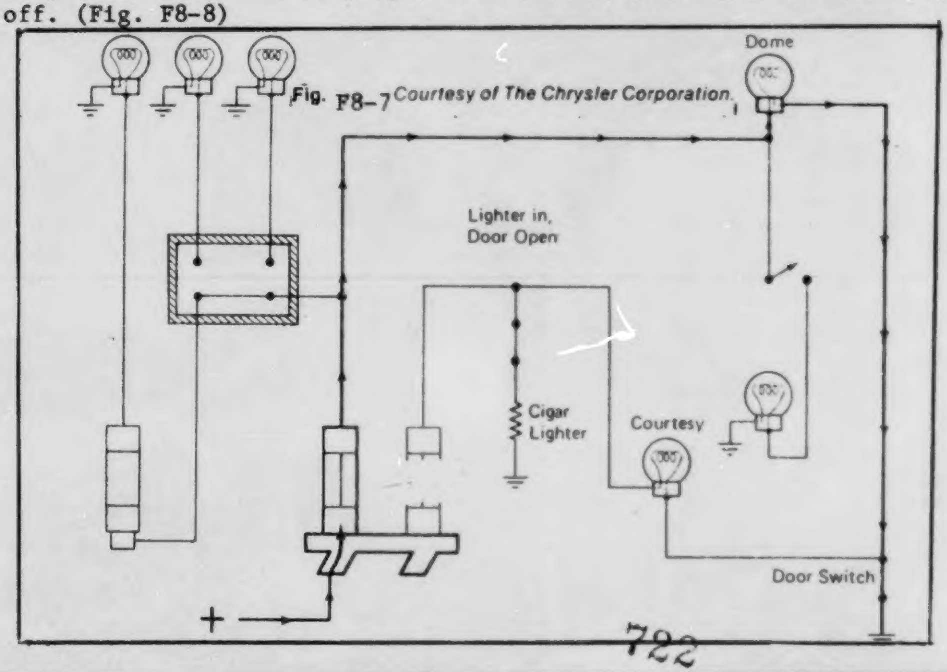

Dome
Not Enough Voltage,
Lighter Won't Release
Courtesy
+

Fig. 8-6 *Courtesy of The Chrysler Corporation.*

You can spot this condition when you open the door (Fig. F8-7). If the dome light gets brighter and the courtesy lights gc oug, you will know that the cigar lighter fuse has burned out. The dome light will be grounded at the door switch allowing the dome light to operate normally. In the same situation with the lighter pushed in and the stoplight switch closed, the dome and courtesy lights will turn off. (Fig. F8-8)

Fig. F8-7 *Courtesy of The Chrysler Corporation.*


Dome
Lighter in,
Door Open
Cigar
Lighter
Courtesy
Door Switch
+

The stoplights will provide a ground before the current gets to the other bulbs.

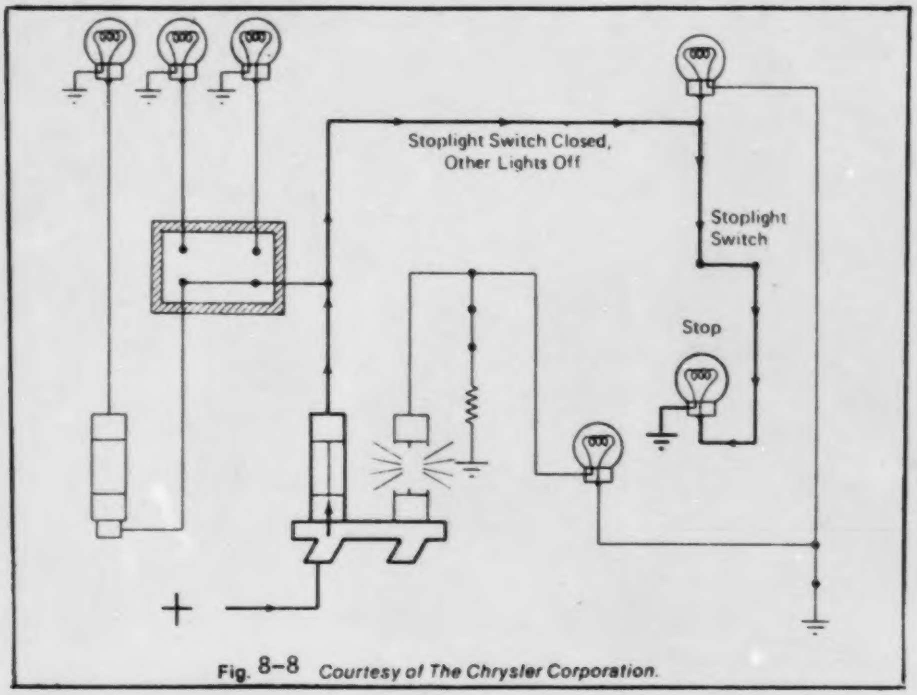


Fig. 8–8 *Courtesy of The Chrysler Corporation.*

Glowing Alternator Signal Light

If the signal light glows with the engine running, and an ammeter test indicates that the alternator is charging, check for a blown fuse in the instrument light panel or a loose connection at the fuse block. It is not unusual to find that a blown fuse has caused a feedback problem and has prevented the light from going out.

Troubleshooting

With a systematic approach, "crazy light" problems can become simple problems. First, don't panic and start tearing a wiring harness apart or replacing unnecessary circuit components. Keep in mind that whatever caused the problem, a feedback was created and electricity picked out a new path (an easier way to go). Fouled-up or crossed wiring is the least of your worries.

Start your procedure with the simple checks first. The following four-step procedure should solve most crazy light problems.

Step 1— Check for a blown or missing fuse in the fuse block.
Step 2 —Turn all the lights on an walk around the car. If a light is out, replace it. Should one light be too bright (two filaments touching each other) or too dim (wrong bulb application or bad ground), solve these obvious problems first before proceeding.
Step 3— Check the car body ground to the chassis and back to the battery.
Step 4 - Check for clean and tight electrical connections in the suspect circuit.

Electrical Competencies- Body & Chassis

No. F-8 Identify Circuit Feedback Using
Wiring Diagrams

Test #1

Name ______________________ Date ________________ Grade ______________

Directions: Select the one best answer for each of the questions.

1. The condition that results in electrical lights and accessories operating without being activated in the normal manner is:
   - a. comeback
   - b. feedback
   - c. modification selection
   - d. circuit diffusion
   - e. articultion

2. If a fuse blows or a ground is faulty, electricity will:
   - a. remain at the consumer or load
   - b. return to the source of power
   - c. increase in amperage
   - d. find another path to follow
   - e. none of the above

3. A glowing alternator signal light could be caused by: (when engine is running)
   - a. blown fuse
   - b. loose connection at the fuse block
   - c. alternator is faulty
   - d. all of the above
   - e. answers a and b

4. The first step in checking for feedback (crazy light) problems is:
   - a. check to see if the load is working
   - b. measure the resistance of the load with an ohmmeter
   - c. tear the wiring harness apart
   - d. start replacing components
   - e. check for a blown or missing fuse

5. Feedback may be caused by:
   - a. a poor ground connection
   - b. a burned out load component
   - c. loose electrical connections
   - d. corroded electrical connections
   - e. all of the above

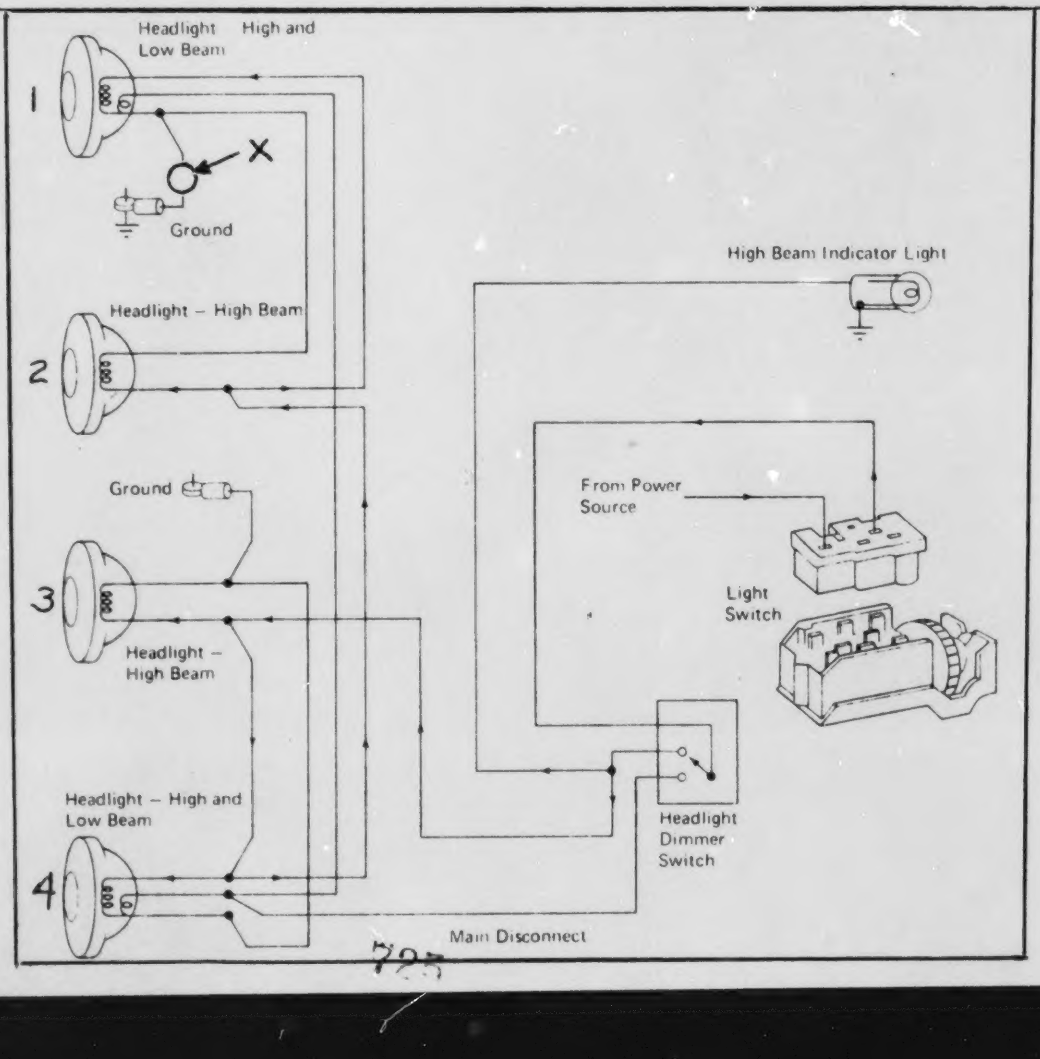
Electrical Competencies- Body & Chassis

No. F-8 Identify Circuit Feedback

Test #2

Name ______________________ Date ____________________ Grade ______________

How would the following headlight circuit perform if the ground wire at point X were open? Briefly explain in the space below which lights would be on in the low beam position, which would be on in the high beam position, and which of the lights would be full bright or dim.


Headlight High and Low Beam
1
X
Ground
High Beam Indicator Light
Headlight – High Beam
2
Ground
From Power Source
3
Light Switch
Headlight – High Beam
Headlight – High and Low Beam
Headlight Dimmer Switch
4
Main Disconnect

AUTO MECHANICS

Electrical Competencies - Body and Chassis

No. F-9 Common Point Diagnosis Using a Wiring Diagram

OBJECTIVE:

Upon completion of the following material, you will be able to conduct a "common point" diagnosis of a circuit.

EXPLANATION:

This unit explains a sub-part of an overall electrical diagnostic procedure.

MATERIALS NEEDED:

Wiring diagram (see competency F-7)

TOOLS NEEDED:

References	Do
1. --	1. Study information sheet #1.
2. --	2. Check with your instructor for assigned component.
3. --	3. Trace the component's circuit using the wiring diagram - in F-7 or a diagram provided by your instructor.
4. --	4. Stop at the first common point and identify the common circuits and their components.
5. --	5. Enter your information on worksheet #1 and complete the remainder of the worksheet.
6. --	6. Turn the worksheet in to your instructor.
7. --	
8. Ch 7. pp. 156-170	

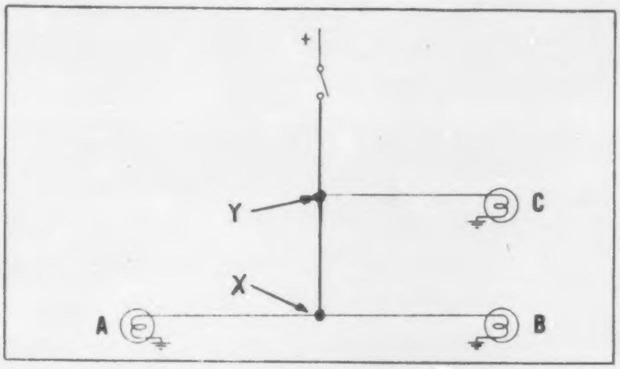
Information Sheet #1

COMMON POINT DIAGNOSIS

Common point diagnosis is a procedure and a method of diagnosis that does not require any test equipment; and yet, can confine an electrical problem to a small section of the total circuit. The only diagnostic aids required are the car wiring diagram and common logic.

Common Point

A common point can be defined as a point in a circuit, furthest away from the power source, where more than one component receives its power. The common point may be a switch, connector, splice, or a short section of wire between two splices. Common points are easy to recognize since they must have additional circuit branching away from them. The figure below shows several "common points."



Point "X" is the first common point since it is furthest away from the power source. This is the common point between the bulbs A and B. (each bulb circuit branches out from point "X").

If both bulbs were not operating properly, we can assume that a problem exists before point "X." If anly one of the bulbs did not operate we could then assume that the problem is after point "X"; in that bulb's branch circuit.

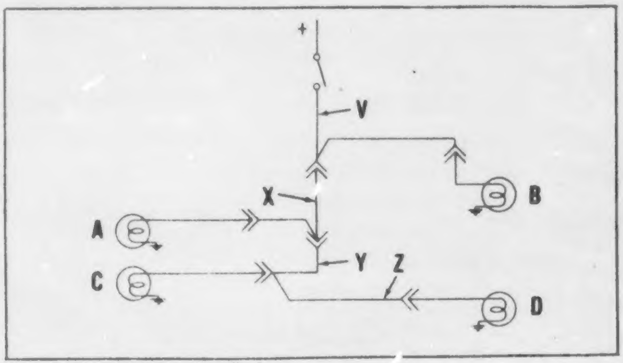
Assuming that we have a problem before point "X," we can now look for an additional common point in the circuit. This we find at point "Y." Point Y is the second common point and is between bulbs A, B, and bulb C.

If light C operated properly while lights A and B didn't, we can assume the problem is after point "Y." We have now isolated a circuit problem to a short section of wire between points "Y" and "X." In doing this we have used only the wire diagram and common logic.

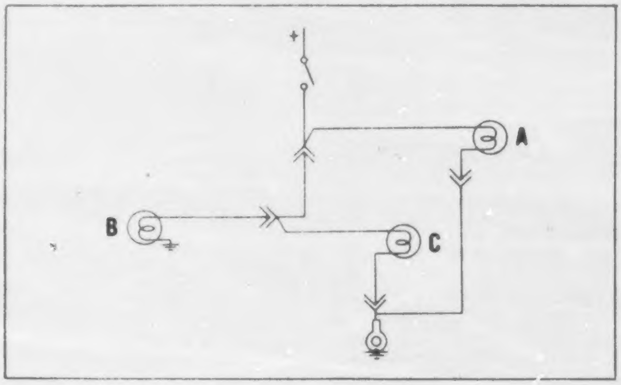
In the above example, if all lights failed to operate, where would you expect to find the problem in the circuit?

F-9 "Common Point" Diagnosis Using a Wiring Diagram

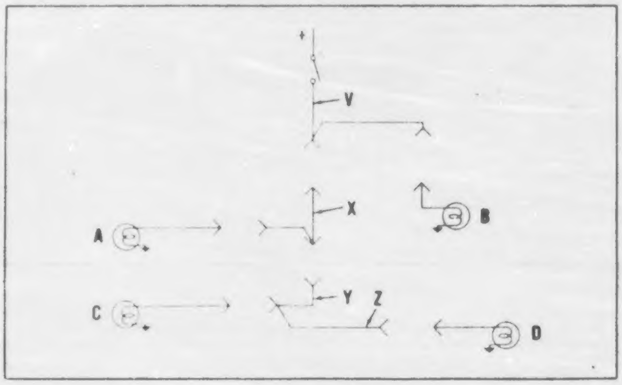
In the circuit shown below, if bulb B is the only bulb working properly, the most likely trouble would be wire section "X." In this circuit, its the only wire that could knock out bulbs A, C, and D. Wire X can be called a common point because it is the only element connecting all three bulbs.



One more thing about common points; they're also sometimes used in ground circuits. In the schematic shown below, bulbs A and C have a common point in their ground circuit. If bulb B worked okay but not bulbs A and C, the most likely cause of the trouble is a missing ground.



Common point diagnosis isolates a trouble to very small pieces of a larger circuit; pieces so small that they're often quickly and easily diagnosed.



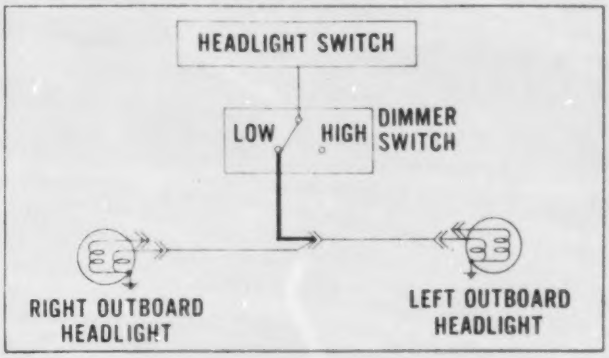
Proper use of common point diagnosis, then, will help you be more efficient, will make it easier for you to find troubles, and over the long haul should save you a lot of time.

You'll find that most of the electrical systems used on our cars are loaded with common points.

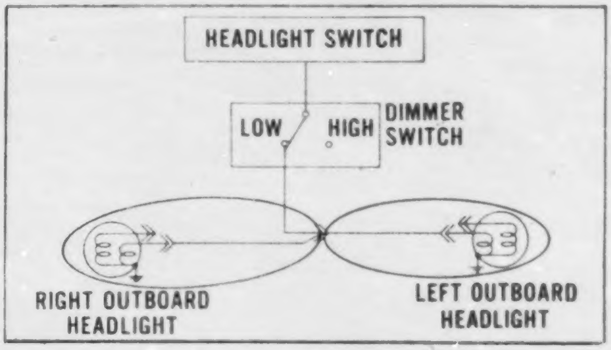
COMMON POINT CIRCUIT EXAMPLES

HEADLIGHT CIRCUIT COMMON POINTS

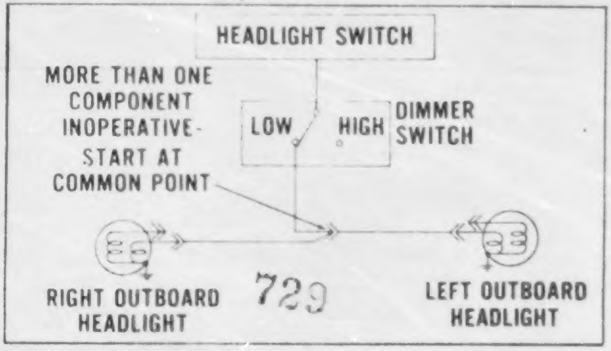
In a low beam circuit like you'd find in the headlight system on some of our cars, the common point between the two bulbs is the wire between the splice and the dimmer switch. If that wire were to open, both bulbs would fail to operate.


HEADLIGHT SWITCH
LOW
HIGH
DIMMER SWITCH
RIGHT OUTBOARD HEADLIGHT
LEFT OUTBOARD HEADLIGHT

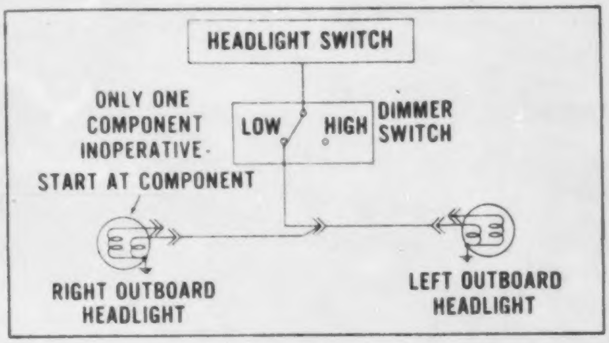
On the other hand, if only one of the bulbs lights, the trouble must be that part of the circuit that's unique to the inoperative bulb; either the bulb itself, the wiring back to the common point, or the ground. This brings up two important diagnosis tips.


HEADLIGHT SWITCH
LOW
HIGH
DIMMER SWITCH
RIGHT OUTBOARD HEADLIGHT
LEFT OUTBOARD HEADLIGHT

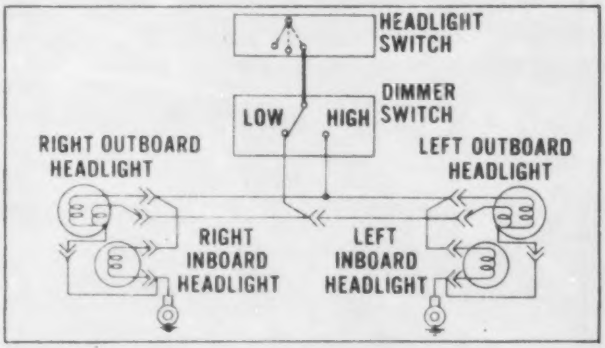
In a multiple load circuit, if more than one component fails to operate properly, start testing at the common point between the inoperative components. In the low beam circuit, that's at the splice near the left outboard headlight.


HEADLIGHT SWITCH
MORE THAN ONE COMPONENT INOPERATIVE-START AT COMMON POINT
LOW
HIGH
DIMMER SWITCH
RIGHT OUTBOARD HEADLIGHT
LEFT OUTBOARD HEADLIGHT

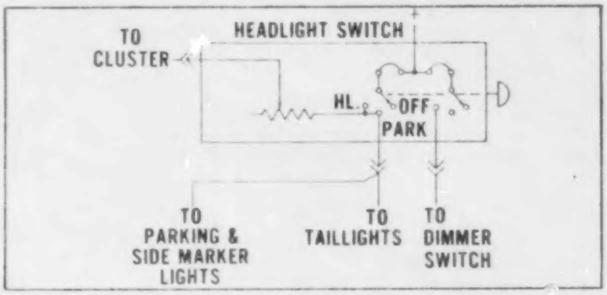
On the other hand, if only one component in a multiple load circuit fails to operate properly, start your testing at that component.


HEADLIGHT SWITCH
ONLY ONE COMPONENT INOPERATIVE-
START AT COMPONENT
LOW
HIGH
DIMMER SWITCH
RIGHT OUTBOARD HEADLIGHT
LEFT OUTBOARD HEADLIGHT

Shown below is the complete headlight circuit for a typical car. The common points between the low beam and high beam circuits are the headlight switch, the dimmer switch, and the wires between them. If the high beams work okay, but the low beams don't, the first test should be made either at the low beam connection of the dimmer switch or at the low beam connector near the left outboard headlight. The best place to test would be at the more accessible of the two.


HEADLIGHT SWITCH
DIMMER SWITCH
LOW
HIGH
RIGHT OUTBOARD HEADLIGHT
LEFT OUTBOARD HEADLIGHT
RIGHT INBOARD HEADLIGHT
LEFT INBOARD HEADLIGHT

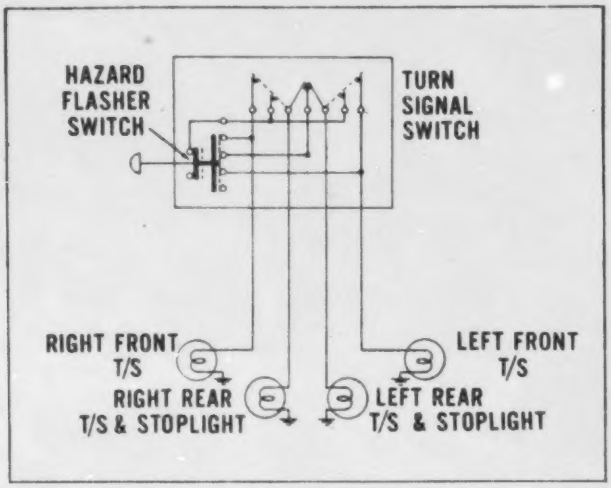
The headlight switch itself, provides a common point that's easily used to diagnose troubles. If some of the circuits, like the parking lights and side marker lights, for example, work okay, but not the headlights, we know right away that we've got power to the switch. That's one test we don't have to make. Again time and effort have been saved.


TO CLUSTER
HEADLIGHT SWITCH
HL
OFF
PARK
TO PARKING & SIDE MARKER LIGHTS
TO TAILLIGHTS
TO DIMMER SWITCH

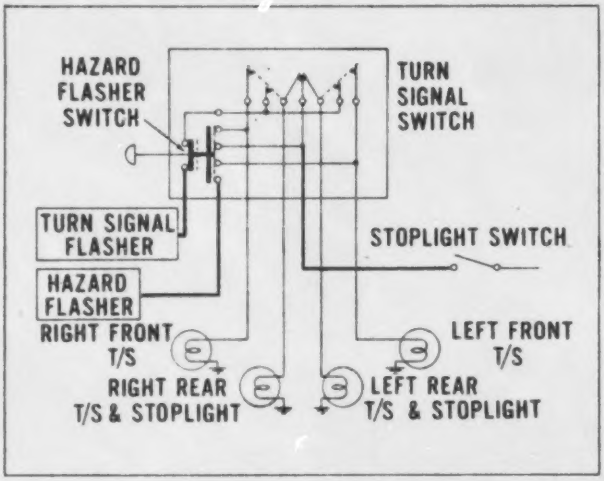
TURN SIGNAL CIRCUIT COMMON POINTS

The Hazard Warning Flasher and Turn Signal circuits found on cars also use a lot of common points. And again, they're useful in diagnosing troubles.

All of the wiring to the turn signal bulbs, of course, is used by both the turn signal and hazard warning circuits. This wiring, then, provides the common points between the two circuits.


HAZARD
FLASHER
SWITCH
TURN
SIGNAL
SWITCH
RIGHT FRONT
T/S
RIGHT REAR
T/S & STOPLIGHT
LEFT REAR
T/S & STOPLIGHT
LEFT FRONT
T/S

If one system functions properly, but the other doesn't, the problem must be in part of the circuit unique to the inoperative system. That is, in the part of the circuit leading to the flasher itself.


HAZARD
FLASHER
SWITCH
TURN
SIGNAL
SWITCH
TURN SIGNAL
FLASHER
STOPLIGHT SWITCH
HAZARD
FLASHER
RIGHT FRONT
T/S
RIGHT REAR
T/S & STOPLIGHT
LEFT REAR
T/S & STOPLIGHT
LEFT FRONT
T/S

The same holds true for the stoplight circuit. If the stoplights don't work, but the turn signals and hazard flashers do, the trouble must be between the turn signal switch and the power feed to the stoplight switch. Utilizing common points and logic will avoid needless, time consuming testing.

Common Point Diagnosis Procedure

I. Verify the complaint

The first step in any diagnosis procedure is to verify the complaint. Try to operate the defective circuit to see if it really doesn't work. As basic as it seems, it's often forgotten.

Make sure you observe all the symptoms particularly in related circuits. You can really cut down on diagnosis time by observing not only what doesn't work okay, but also what does.

II. Locate the components on a wiring diagram

Depending on the type of diagram you are using, this may be done by finding the component listed in an index and using the diagram's grid system or by simply inspecting the diagram. Most components on diagrams without a grid system will be located in an approximate relationship to actual location on the vehicle.

III. Locate common points and common circuits

Once the component has been located, you should be able to trace the circuit to its first common point. At the common point, note the common circuits. This may require tracing each common branch to locate its component for identification.

IV. Try the components on common circuits and use logic

Return to the automobile and actually try the common circuits. Note their operation. Based on your knowledge of common point diagnosis, determine if the circuit problem is before or after your common point. If you find that the problem is before your common point, you can return to the wiring diagram to locate any second common point which may exist. Try the additional common circuits to further isolate the problem.

V. Test the circuit

Proceed to actual testing points in the circuit using the appropriate test equipment and methods.

The above common point diagnosis is included in an overall Systematic Diagnosis Procedure. See Competency F-10, Perform Systematic Diagnosis and Testing.

Electrical Competencies - Body and Chassis

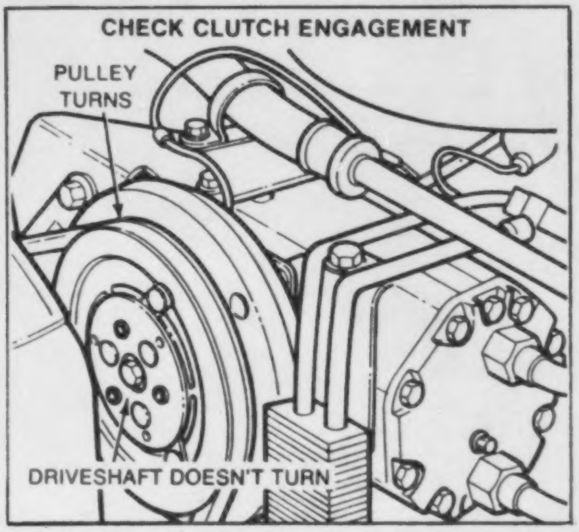
F-9 "Common Point" Diagnosis Using a Wiring Diagram

Information Sheet #2

Troubleshooting Exercise

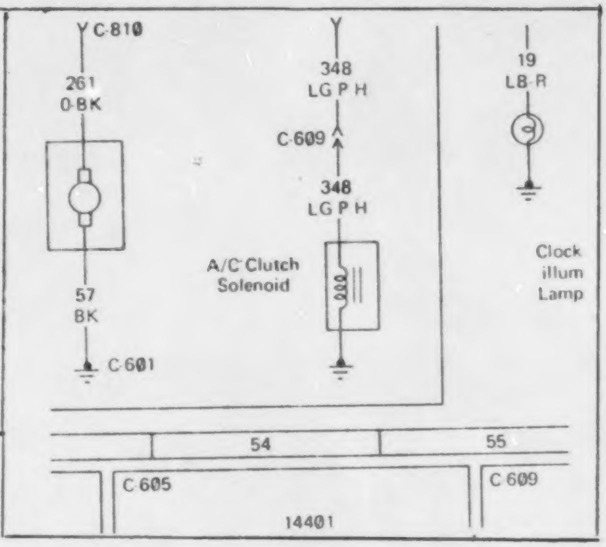
For our test case we'll take a complaint of an air-conditioning system that doesn't cool on a Ford Motor Company passenger car. Keep in mind that the following procedure is adaptable to any car and any wiring diagram.

Step 1 Verify Complaint. To verify the complaint, turn on the air conditioning and note the symptoms. In this case the blower works normally, but the air remains warm after several minutes of operation. It is also noted that the engine appears to lack a compressor load and an under-the-hood inspection reveals that the compressor clutch is not engaged. The pully is turning, but the compressor driveshaft is not, an indication that the compressor clutch solenoid is not holding.

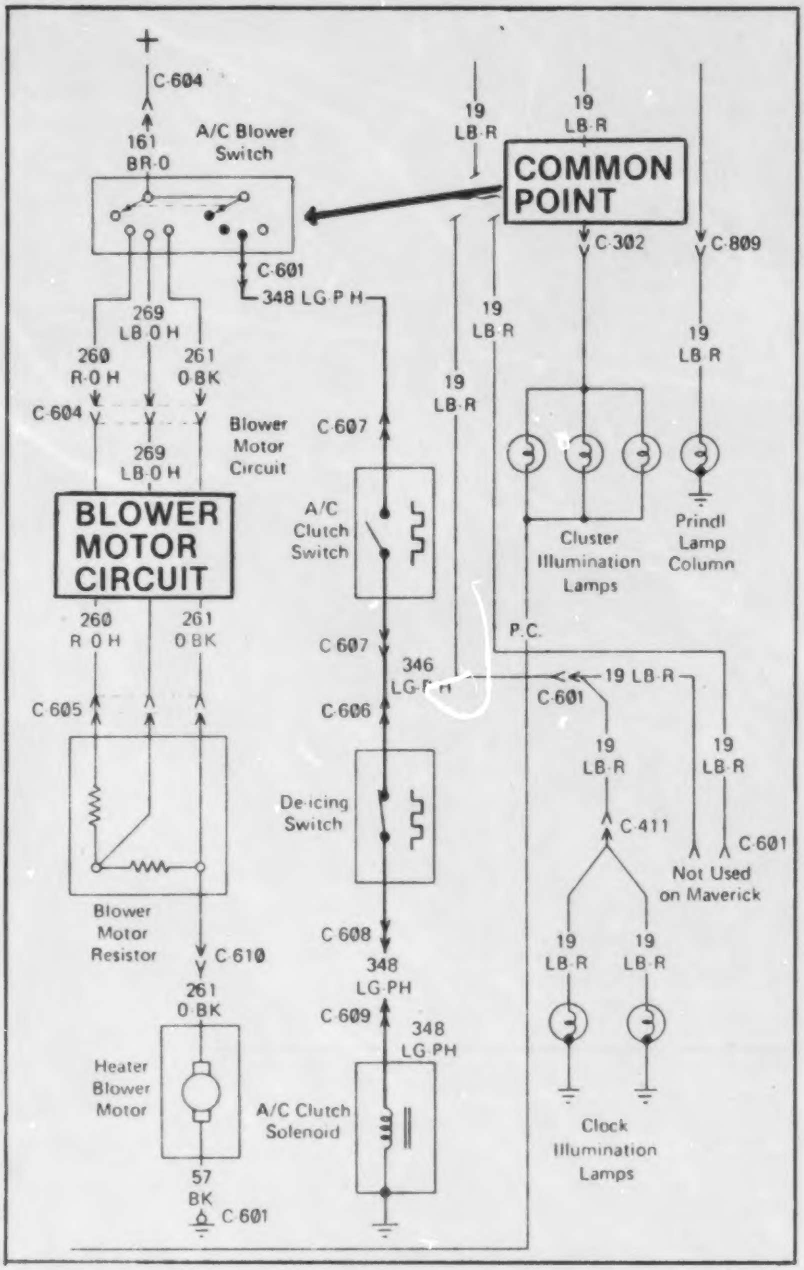


Step 2 Locate on Schematic. Locate the inoperative component, the air-conditioning clutch solenoid, on the diagram. On Ford Motor Company vehicles, components are easily located in the wiring diagram from a location index code. The location code in this case is found to be F-54. Once the clutch solenoid is located in the wiring diagram, the circuit can be traced back to a common point.

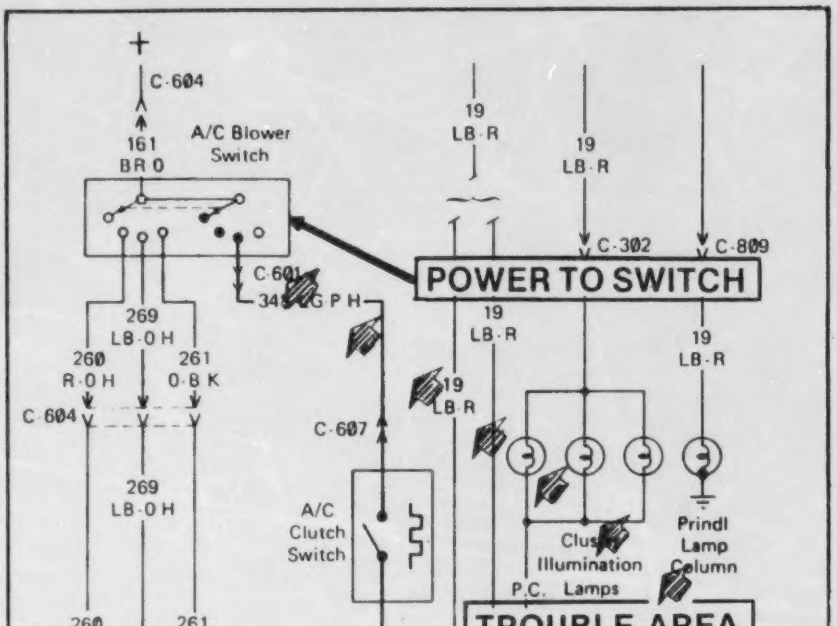
Alternator	A-1
Alternator Regulator	F-2
Battery	B-3
Blower Motor Resistor A/C	E-53
Blower Motor Resistor Htr.	E-51
Cigar Lighter	E-24
Clock	E-23
Constant Voltage Unit	E-22
Distributor 6 Cylinder	D-4
Distributor 8 Cylinder	F-4
Electric Choke	D-5
Emission Heater	F-50
Emission Control Solenoid	D-7
Flashers	
Emergency Warning	C-24
Turn Signal	C-40



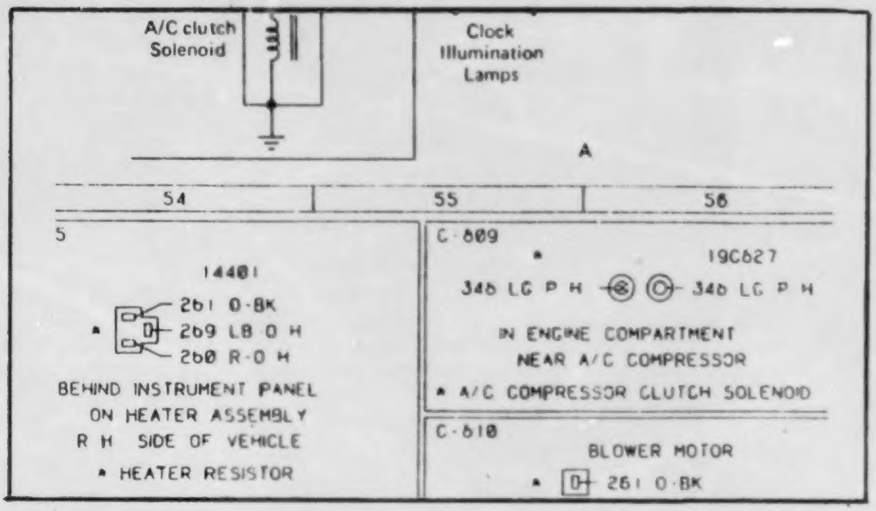
Step 3 Locate Common Point. In our example, by tracing back on the circuit, a common point is found with the blower circuit at the blower switch. If the blower works, there is power to the switch.


+
C 604
161
BR-O
A/C Blower Switch
19
LB-R
19
LB-R
COMMON POINT
C 302
C 809
C 601
348 LG-P H
269
LB-O H
260
R-O H
261
O-BK
C 604
Blower Motor Circuit
269
LB-O H
BLOWER MOTOR CIRCUIT
C 607
A/C Clutch Switch
19
LB-R
19
LB-R
19
LB-R
Cluster Illumination Lamps
Prindl Lamp Column
260
R-O H
261
O-BK
P.C.
C 607
346
LG-P H
19 LB-R
C 605
C 606
C 601
19
LB-R
19
LB-R
De-icing Switch
C 411
C 601
Not Used on Maverick
Blower Motor Resistor
C 608
C 610
348
LG-PH
19
LB-R
19
LB-R
261
O-BK
C 609
348
LG-PH
Heater Blower Motor
A/C Clutch Solenoid
Clock Illumination Lamps
57
BK
C 601

Step 4 Try Common Component. Since the blower motor works, it can be concluded that there is power to the switch. Therefore the trouble must be somewhere between the blower switch and clutch solenoid (see below.) Without making one electrical instrument test we have confined the problem on paper to a specific area. We're now ready for the next step, in which we apply our paper work findings to the car.

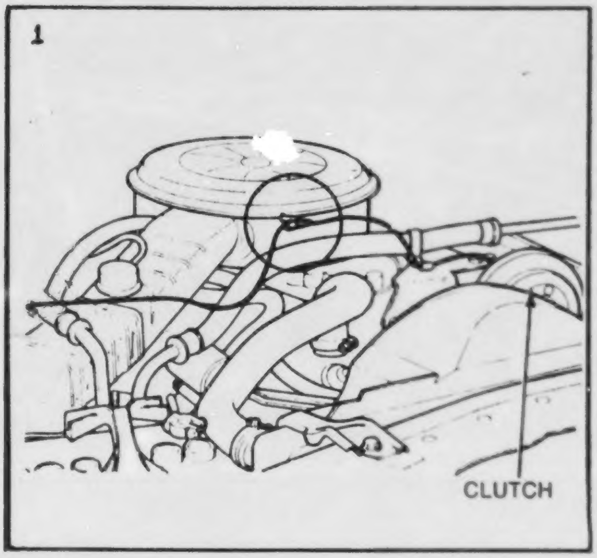

+
C-604
161
BR O
A/C Blower Switch
C-601
346 LG-P H
POWER TO SWITCH
19
LB-R
C-302
C-809
269
LB-O H
260
R-O H
261
O-B K
C-604
C-607
A/C Clutch Switch
Cluster Illumination Lamps
P.C.
Prindl Lamp Column
TROUBLE AREA
C-605
C-606
346
LG-P H
C-601
C-411
Not Used on Maverick
Blower Motor Resistor
De-icing Switch
C-608
348
LG-PH
C-610
C-609
Heater Blower Motor
A/C Clutch Solenoid
Clock Illumination Lamps
57
BK

Step 5 Make Electrical Tests. Using the wiring diagram, again check the locations of the connectors in the isolated trouble area. Note below that each connector has a code number and the locations can be checked out with the wiring diagram connector graphics. Connection C-809 is easily accessible and is a bullet connector in the engine compartment located near the compressor. (Fig. 1)

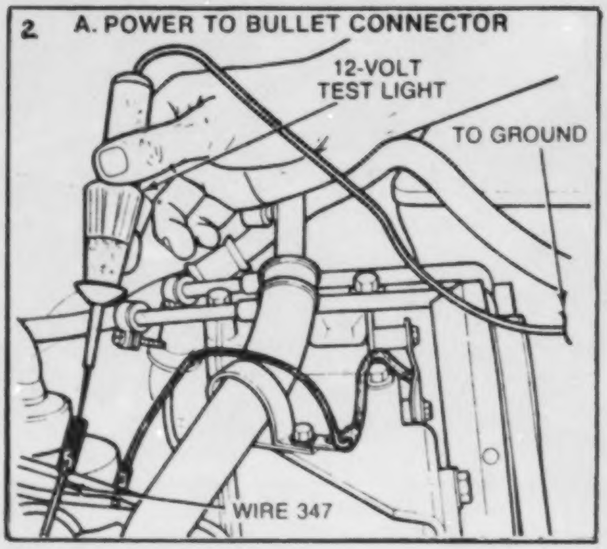

A/C clutch
Solenoid
Clock
Illumination
Lamps
A
54
55
56
5
14401
261 O-BK
269 LB-O H
260 R-O H
BEHIND INSTRUMENT PANEL
ON HEATER ASSEMBLY
R H SIDE OF VEHICLE
* HEATER RESISTOR
C-809
*
19C627
346 LG P H
346 LG P H
IN ENGINE COMPARTMENT
NEAR A/C COMPRESSOR
* A/C COMPRESSOR CLUTCH SOLENOID
C-610
BLOWER MOTOR
*
261 O-BK

Power to the solenoid is from the female end of the connector. With a test light it is found that there is no power at this connector. (Fig. 2)

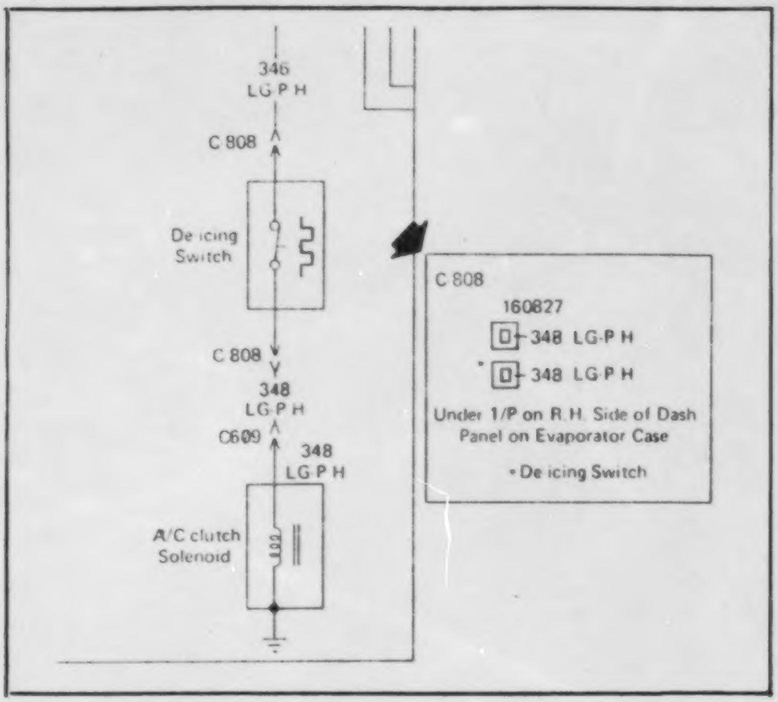
1



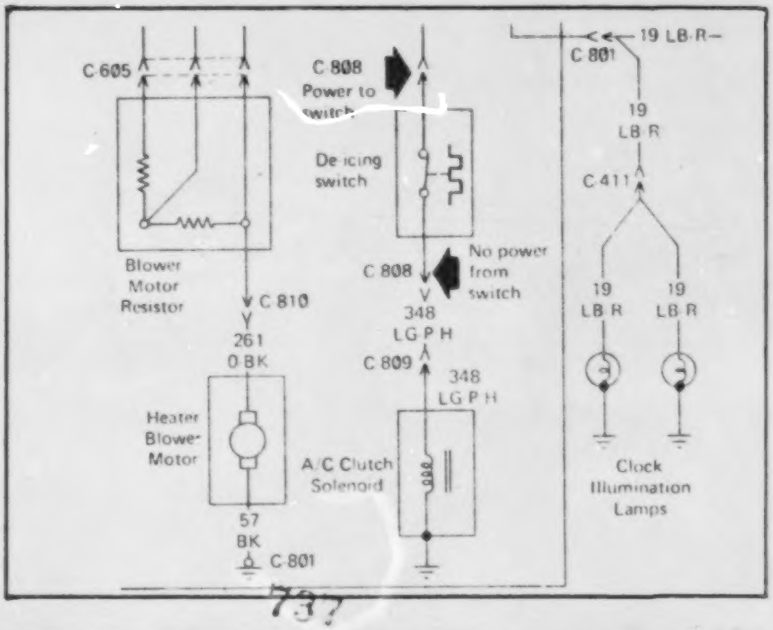
2 A. POWER TO BULLET CONNECTOR


12-VOLT
TEST LIGHT
TO GROUND
WIRE 347

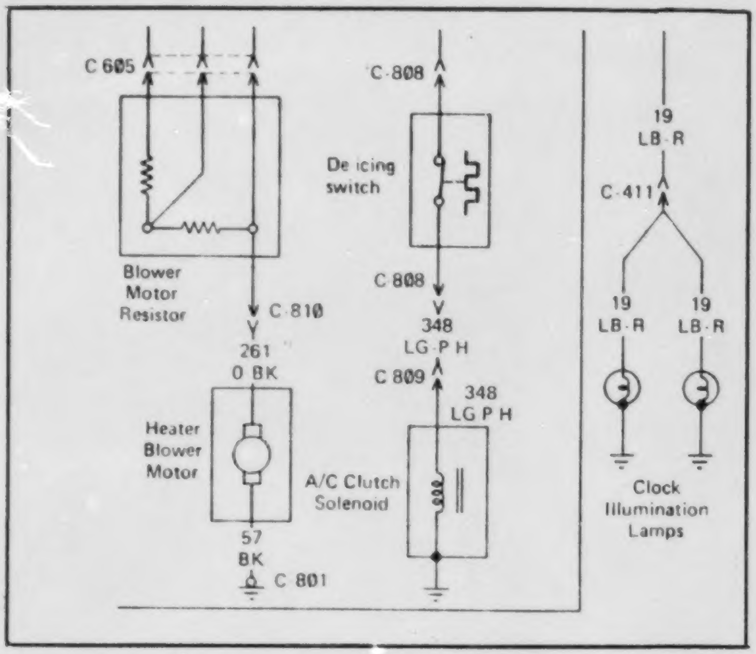
The next logical step is to proceed to the next connector point, which is at the deicing switch connector, C-808. The connector graphics tells us that connector C-808 is located under the instrumental panel on the evaporator case and that there are two test points.


346
LG-P H
C 808
De icing
Switch
C 808
348
LG-P H
C609
348
LG-P H
A/C clutch
Solenoid
C 808
160827
348 LG-P H
348 LG-P H
Under 1/P on R.H. Side of Dash
Panel on Evaporator Case
• De icing Switch

Using the test light again for a quick power check at these two test points, it is found that there is power to the switch, but no power from the switch.


C 605
C 808
Power to
switch
De icing
switch
No power
from
switch
C 808
348
LG-P H
C 809
348
LG-P H
A/C Clutch
Solenoid
Blower
Motor
Resistor
C 810
261
0-BK
Heater
Blower
Motor
57
BK
C 801
19 LB-R
C 801
19
LB-R
C 411
19
LB-R
19
LB-R
Clock
Illumination
Lamps

From thest test indications it can be concluded that the switch is probably at fault. A positive check of the switch with a continuity test verifies that it is open and should be replaced (see below).


C 605
C-808
De icing switch
19
LB-R
C-411
Blower Motor Resistor
C 810
261
0 BK
C 808
348
LG-P H
C 809
348
LG P H
19
LB-R
19
LB-R
Heater Blower Motor
A/C Clutch Solenoid
Clock Illumination Lamps
57
BK
C 801

Don't forget to back up your diagnosis with two more steps:

Step 6 Repair the defect

Step 7 Operate the circuit to check that the repair was successful in correcting the complaint.

F-9 "Common Point" diagnosis Using a Wiring Diagram

Worksheet #1

Name ________________________________ Date ________________ Grade ______________

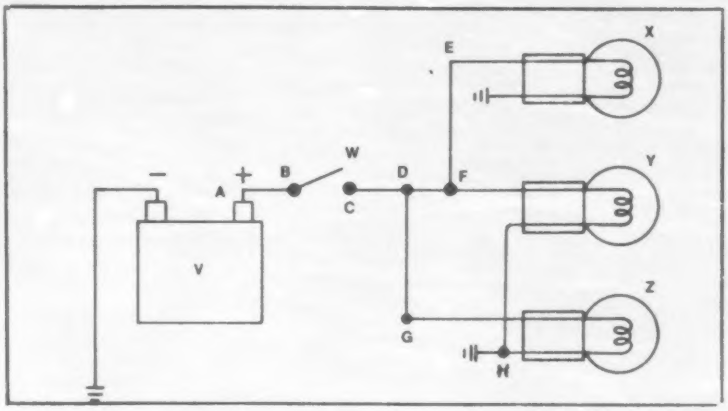
Instructions: Obtain a component and wiring diagram assignment from your instructor. Use the diagram to trace the component to its first common point. Identify all the Common circuits and list this information in space No. 1 below.

Vehicle ________________________________ Year ____________

1. List circuits in common with assigned component

2. What is the common point diagnosis procedure?

3. Answer questions a. through j. by refering to the letter code in the wiring diagram provided (assume all bulbs are OK).



a. What is the first common point in this circuit?__________

b. Which two bulbs are in common with the first common point? __________

c. If only lamp "Y" failed to operate, what section of the feed circuit would be at fault?__________

d. If both lamp "X" and lamp "Y" failed to operate, what section of the circuit would be at fault?__________

e. If both lamps "Y" and "Z" failed to operate, what section of the circuit would be at fault? __________________

f. If both lamp "X" and lamp "Y" operated properly, but lamp "Z" did not, what section of the circuit would be at fault? ______________________

g. If both lamp "X" and lamp "Y" failed to operate, but lamp "Z" operated, what section of the circuit would be at fault? ___________________________

h. If only lamp "Y" operated properly what sections of the circuit would be at fault?_________________________________

i. If all lamps failed to operate properly, what section of the circuit would be at fault? ________________________________

j. If both section (D-F) and section (H-ground) were open, what would be the observable result?_________________________________

AUTO MECHANICS

Electrical Competencies - Body & Chassis

No. F-10 Perform Systematic Diagnosis and Testing

OBJECTIVE:

Upon completion of the following material, you will be able to systematically diagnose and test an automotive electrical system problems.

EXPLANATION:

This unit covers common electrical problems and gives examples of systematic diagnosis

MATERIALS NEEDED:

Wiring diagram

TOOLS NEEDED:

References	Do
#1. --	#1. Read instruction sheets
#2. --	#2. Check with instructor for assigned electrical system malfunction
#3. --	#3. Use systematic diagnosis and testing procedures to correct malfunction
#4. --	#4. Explain the steps you used in repair in Worksheet #.
#5. --	#5. Turn Worksheet in for instructor check
#6. --	
#7. --	
#8. --	

Electrical Competencies - Body & Chassis

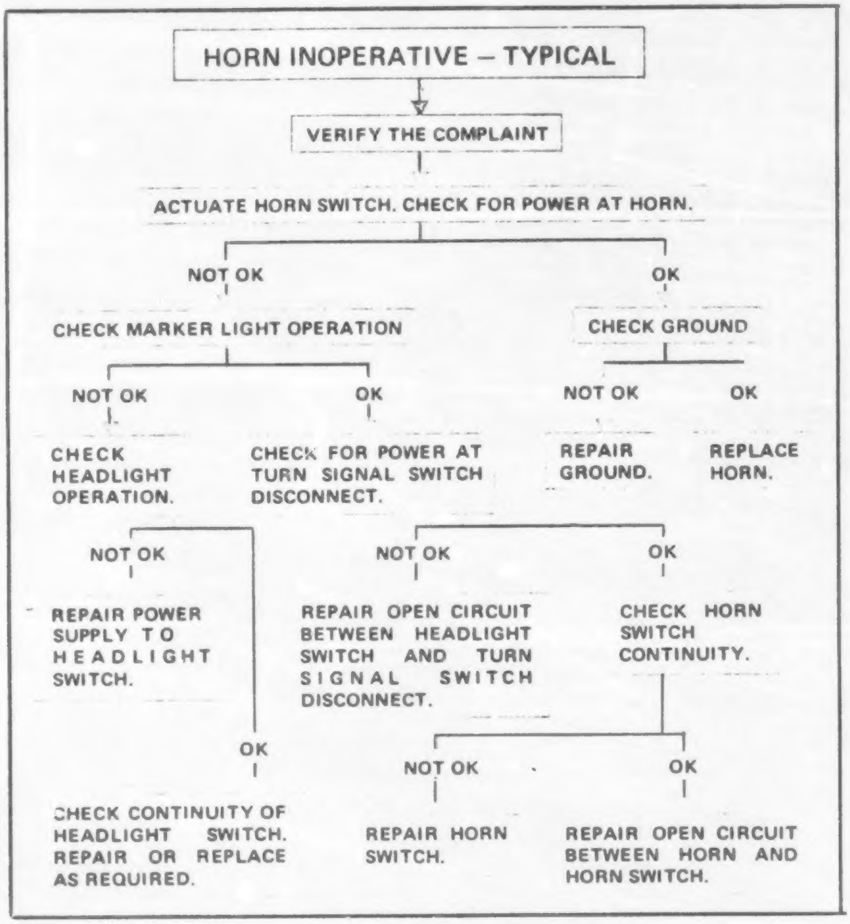
No. F-10 Perform Systematic Diagnosis and Testing

Information Sheet #1

What is Systematic Diagnosis?

A systematic electrical trouble shooting plan is an organized logical sequence procedure for identifying and tracing an electrical problem from the trouble to the correction.

Below is a typical diagnosis chart found in Ford's Car Shop Manual. A similar chart is used by American Motors and Chrysler Corporations. Note that this type of diagnostic aid takes you step by step in a logical sequence from the original problem to its correction. Along the way, the chart separates live and ground circuits and divides the test sequence at common points. For actual circuit testing, the diagnosis steps list the test points. Do not confuse this systematic plan with typical trouble shooting guides. (The major differences will be covered later.)


HORN INOPERATIVE – TYPICAL
VERIFY THE COMPLAINT
ACTUATE HORN SWITCH. CHECK FOR POWER AT HORN.
NOT OK
OK
CHECK MARKER LIGHT OPERATION
CHECK GROUND
NOT OK
OK
NOT OK
OK
CHECK HEADLIGHT OPERATION.
CHECK FOR POWER AT TURN SIGNAL SWITCH DISCONNECT.
REPAIR GROUND.
REPLACE HORN.
NOT OK
NOT OK
OK
REPAIR POWER SUPPLY TO HEADLIGHT SWITCH.
REPAIR OPEN CIRCUIT BETWEEN HEADLIGHT SWITCH AND TURN SIGNAL SWITCH DISCONNECT.
CHECK HORN SWITCH CONTINUITY.
OK
NOT OK
OK
CHECK CONTINUITY OF HEADLIGHT SWITCH. REPAIR OR REPLACE AS REQUIRED.
REPAIR HORN SWITCH.
REPAIR OPEN CIRCUIT BETWEEN HORN AND HORN SWITCH.

TYPICAL DIAGNOSIS CHART

A General Motors pictorial diagnosis chart is presented on the next page. The chart includes all the same information as the "flow chart" type diagnosis example on page one, however, the format is vastly different and unique to the industry. Instructions for its use and the symbol key are shown below.

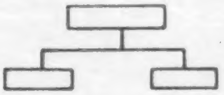
DIAGNOSIS

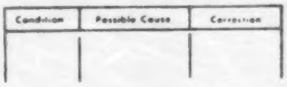
DIAGNOSIS CHARTS

SEAT BELT / STARTER INTERLOCK SYSTEM

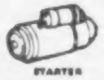
Introduction

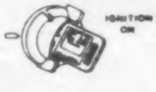
This section presents a systematic method of diagnosing and troubleshooting the seat belt/starter interlock system. The charts you will be using are different from the ones you have used before. They aren't "go —no go" decision trees or tables.

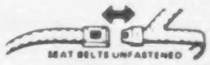



Condition
Possible Cause
Correction

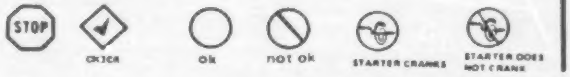
Instead the new diagnosis and troubleshooting charts use pictures plus a few words to help you solve a problem,




IGNITION ON

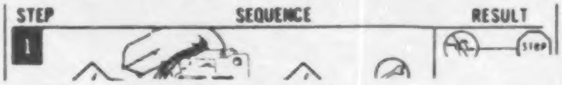

SEAT BELTS UNFASTENED

and symbols have replaced words.

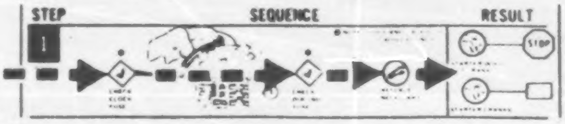

STOP
CHECK
ok
not ok
STARTER CRANKS
STARTER DOES NOT CRANK

How to use the charts

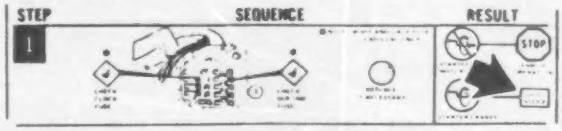
The charts are divided into three sections: step, sequence and result.


STEP
SEQUENCE
RESULT
1
STOP

Always start at the first step and go through the complete sequence from left to right.


STEP
SEQUENCE
RESULT
1
STOP

A sequence could be checking the fuses and replacing if necessary. Each sequence ends with a result and tells you the next step to go to.

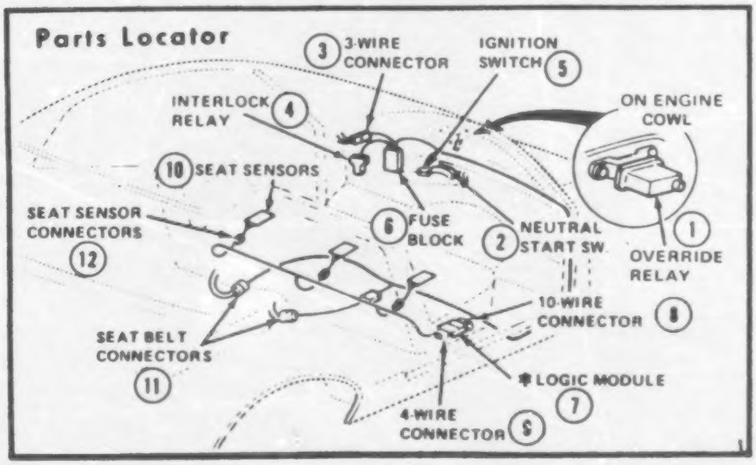

STEP
SEQUENCE
RESULT
1
STOP

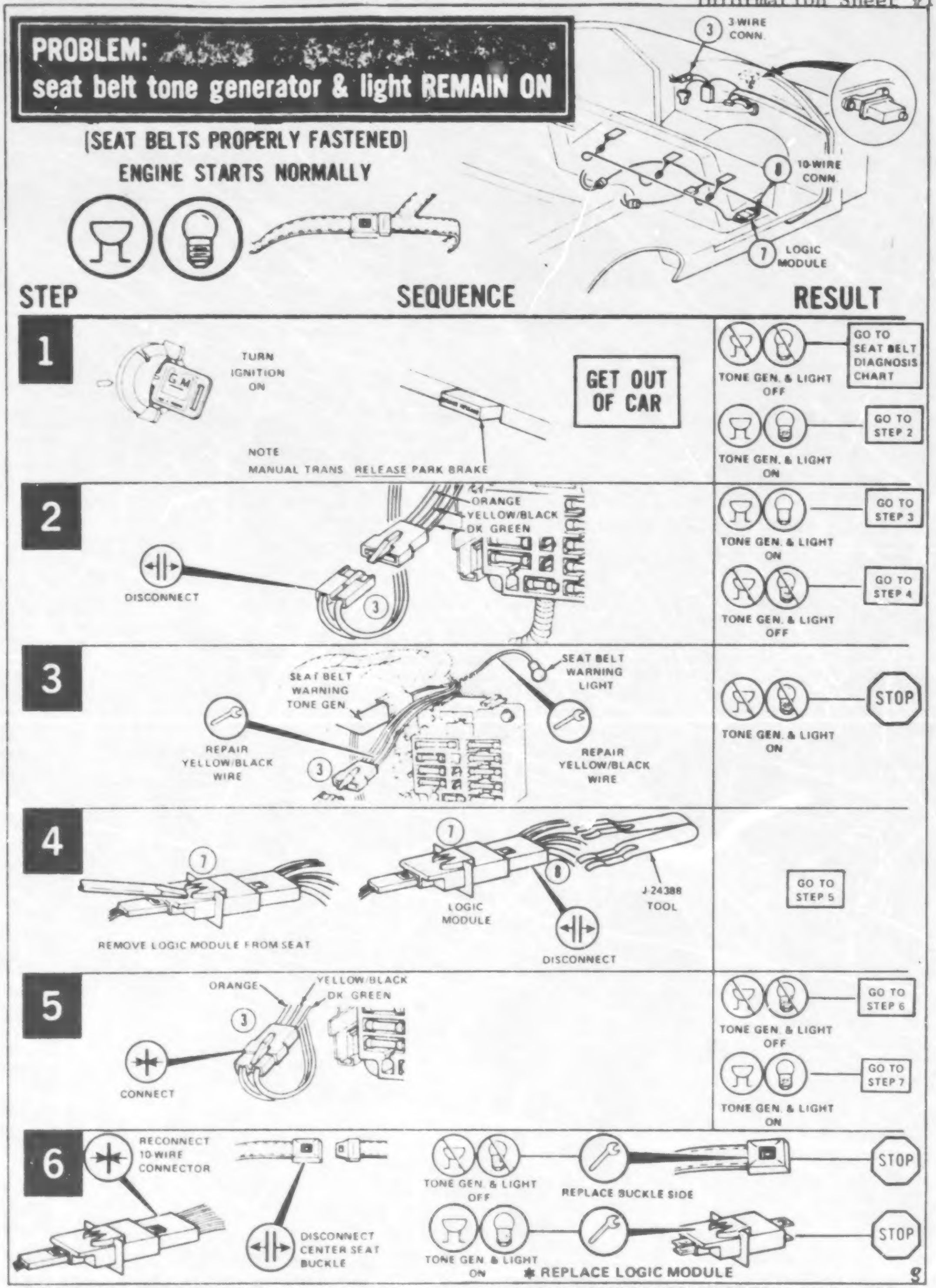
Work through each step of the diagnosis and trouble shooting charts till the system is repaired. STOP

To find where parts are located in the system just look at the parts locator at the top of each chart.

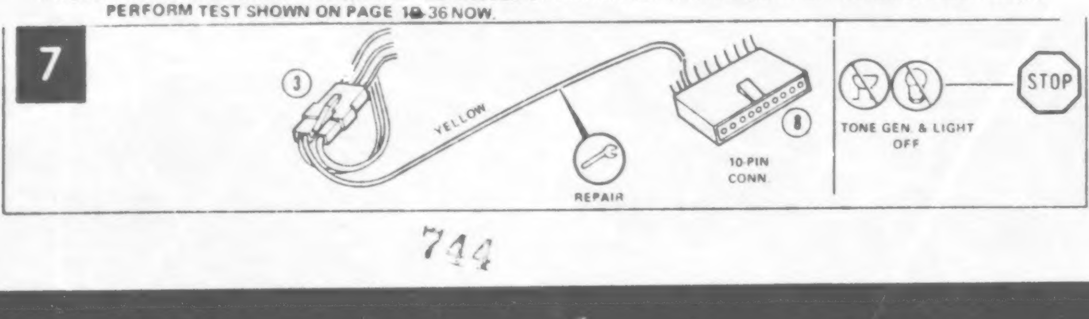
Index

1. Starter WILL NOT CRANK
Page 1B-24
2. Starter CRANKS with seat belt UNFASTENED
Page 1B-27
3. Seat belt buzzer & light WILL NOT OPERATE
Page 1B-28
4. Seat belt buzzer & light REMAIN ON
Page 1B-30
5. SEAT BELT SYSTEM DIAGNOSIS
Page 1B-31
6. TROUBLESHOOTING INTERLOCK CONTROL AND TONE GENERATOR
Page 1B-36


Parts Locator
③ 3-WIRE CONNECTOR
IGNITION SWITCH ⑤
INTERLOCK RELAY ④
ON ENGINE COWL
⑩ SEAT SENSORS
SEAT SENSOR CONNECTORS ⑫
⑥ FUSE BLOCK
② NEUTRAL START SW.
① OVERRIDE RELAY
10-WIRE CONNECTOR ⑧
SEAT BELT CONNECTORS ⑪
* LOGIC MODULE ⑦
4-WIRE CONNECTOR ⑨


PROBLEM:
seat belt tone generator & light REMAIN ON
(SEAT BELTS PROPERLY FASTENED)
ENGINE STARTS NORMALLY
③ 3 WIRE CONN.
⑧ 10-WIRE CONN.
⑦ LOGIC MODULE
STEP
SEQUENCE
RESULT
1
TURN IGNITION ON
GET OUT OF CAR
NOTE
MANUAL TRANS. RELEASE PARK BRAKE
TONE GEN. & LIGHT OFF
GO TO SEAT BELT DIAGNOSIS CHART
TONE GEN. & LIGHT ON
GO TO STEP 2
2
ORANGE
YELLOW/BLACK
DK. GREEN
DISCONNECT
③
TONE GEN. & LIGHT ON
GO TO STEP 3
TONE GEN. & LIGHT OFF
GO TO STEP 4
3
SEAT BELT WARNING TONE GEN.
SEAT BELT WARNING LIGHT
REPAIR YELLOW/BLACK WIRE
REPAIR YELLOW/BLACK WIRE
③
TONE GEN. & LIGHT ON
STOP
4
⑦
REMOVE LOGIC MODULE FROM SEAT
LOGIC MODULE
⑧
J-24388 TOOL
DISCONNECT
GO TO STEP 5
5
ORANGE
YELLOW/BLACK
DK. GREEN
③
CONNECT
TONE GEN. & LIGHT OFF
GO TO STEP 6
TONE GEN. & LIGHT ON
GO TO STEP 7
6
RECONNECT 10-WIRE CONNECTOR
DISCONNECT CENTER SEAT BUCKLE
TONE GEN. & LIGHT OFF
REPLACE BUCKLE SIDE
STOP
TONE GEN. & LIGHT ON
✱ REPLACE LOGIC MODULE
STOP

✱ NOTE: FAILURE OF LOGIC MODULE MAY BE CAUSED BY A SHORTED INTERLOCK RELAY OR TONE GENERATOR. PERFORM TEST SHOWN ON PAGE 1B-36 NOW.


7
③
YELLOW
REPAIR
⑧
10-PIN CONN.
TONE GEN. & LIGHT OFF
STOP

Trouble-Shooting Guides

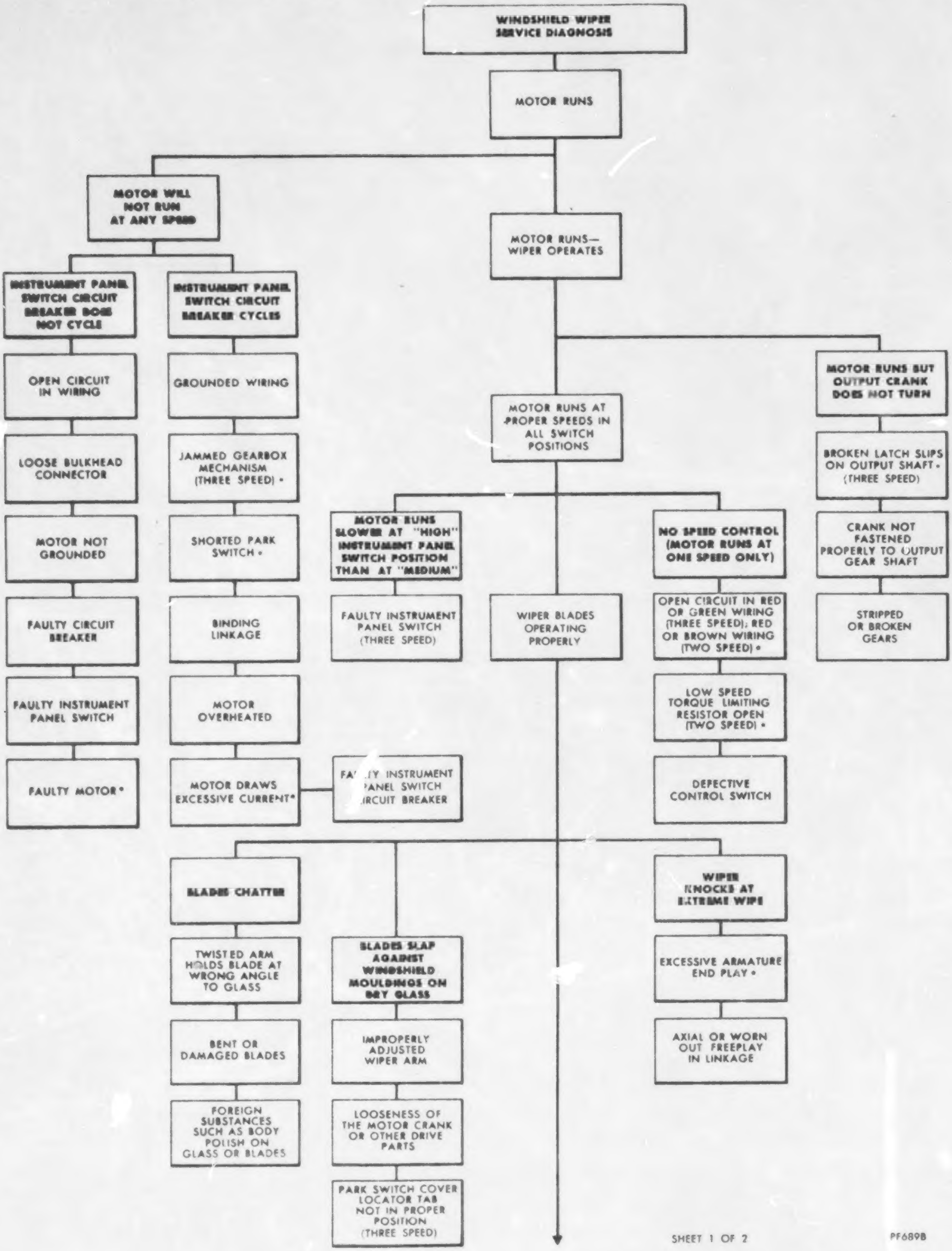
Trouble-shooting guides differ from systematic diagnosis charts in that they do not provide a logical sequence of testing steps. Typical charts are based on a list of observable component malfunction conditions. Fo each condition, a list of possible causes is provided without a testing sequence. An example of this type of guide is shown below.

Trouble-shooting guides may also be presented in a "flow chart" pattern as in the Chrysler Corporation chart on the next page.Although this looks like a systematic diagnosis chart, note that the boxes under each malfunction only provide a list of possible causes and not a specific test sequence. Trouble-shooting charts are typically general in nature and applicable to all types of vehicles.

DIAGNOSIS

HEADLAMP DIAGNOSIS

Condition	Possible Cause	Correction
One headlamp inoperative or intermittent	1. Loose connection	1. Secure connections to sealed beam including ground. (Black Wire)
	2. Sealed Beam Malfunction	1. Replace sealed beam
One or more headlights are dim.	1. Open ground connection at headlight	1. Repair black wire connection between sealed beam and body ground.
	2. Black ground wire mislocated in headlight connector (type 2 sealed beam)	1. Relocate black wire in connector
One or more headlights short life	1. Voltage regulator malfunction	1. Replace voltage regulator
All headlights inoperative or intermittent	1. Loose connection	1. Check and secure connections at dimmer switch and light switch.
	2. Dimmer switch malfunction	1. Check voltage at dimmer switch with test lamp. If test lamp bulb lights only at light blue wire terminal, replace dimmer switch.
	3. Open wiring - light switch to dimmer switch	1. Check light blue wire with test lamp. If bulb lights at light switch light blue wire terminal but not at dimmer switch, repair open wire.


WINDSHIELD WIPER SERVICE DIAGNOSIS
MOTOR RUNS
MOTOR WILL NOT RUN AT ANY SPEED
INSTRUMENT PANEL SWITCH CIRCUIT BREAKER DOES NOT CYCLE
OPEN CIRCUIT IN WIRING
LOOSE BULKHEAD CONNECTOR
MOTOR NOT GROUNDED
FAULTY CIRCUIT BREAKER
FAULTY INSTRUMENT PANEL SWITCH
FAULTY MOTOR*
INSTRUMENT PANEL SWITCH CIRCUIT BREAKER CYCLES
GROUNDED WIRING
JAMMED GEARBOX MECHANISM (THREE SPEED) •
SHORTED PARK SWITCH •
BINDING LINKAGE
MOTOR OVERHEATED
MOTOR DRAWS EXCESSIVE CURRENT*
FAULTY INSTRUMENT PANEL SWITCH CIRCUIT BREAKER
MOTOR RUNS—WIPER OPERATES
MOTOR RUNS AT PROPER SPEEDS IN ALL SWITCH POSITIONS
MOTOR RUNS SLOWER AT "HIGH" INSTRUMENT PANEL SWITCH POSITION THAN AT "MEDIUM"
FAULTY INSTRUMENT PANEL SWITCH (THREE SPEED)
WIPER BLADES OPERATING PROPERLY
NO SPEED CONTROL (MOTOR RUNS AT ONE SPEED ONLY)
OPEN CIRCUIT IN RED OR GREEN WIRING (THREE SPEED); RED OR BROWN WIRING (TWO SPEED) •
LOW SPEED TORQUE LIMITING RESISTOR OPEN (TWO SPEED) •
DEFECTIVE CONTROL SWITCH
MOTOR RUNS BUT OUTPUT CRANK DOES NOT TURN
BROKEN LATCH SLIPS ON OUTPUT SHAFT • (THREE SPEED)
CRANK NOT FASTENED PROPERLY TO OUTPUT GEAR SHAFT
STRIPPED OR BROKEN GEARS
BLADES CHATTER
TWISTED ARM HOLDS BLADE AT WRONG ANGLE TO GLASS
BENT OR DAMAGED BLADES
FOREIGN SUBSTANCES SUCH AS BODY POLISH ON GLASS OR BLADES
BLADES SLAP AGAINST WINDSHIELD MOULDINGS ON DRY GLASS
IMPROPERLY ADJUSTED WIPER ARM
LOOSENESS OF THE MOTOR CRANK OR OTHER DRIVE PARTS
PARK SWITCH COVER LOCATOR TAB NOT IN PROPER POSITION (THREE SPEED)
WIPER KNOCKS AT EXTREME WIPE
EXCESSIVE ARMATURE END PLAY •
AXIAL OR WORN OUT FREEPLAY IN LINKAGE
SHEET 1 OF 2
PF6898

Using Diagnosis Charts or Guides

Whether you use a systematic diagnosis chart or a trouble-shooting guide, there are basic skills and knowledge, that you will need to complete a successful electrical system diagnosis. These include:

1. Having a basic knowledge of electrical circuits and electrical properties.
2. The ability to locate components and specific wires on a wiring diagram and on the car.
3. The ability to make and interpret tests such as for power and continuity and for location of shorts and opens. This involves the use of a test light ohmmeter, voltmeter, ammeter, jumper wires, and rheostat.
4. The ability to deal with the problem by using simple tests first and more complex tests later in the procedure.
5. The ability to be able to think in terms of what is right with the problem circuit before concluding what is wrong.

Although the use of diagnostic aids can be very helpful, you'll find that such charts and guides are not available for every complaint. Having the basic talents that the use of such charts call for, however, and a schematic diagram of the system, you can, with a little thought, develop your own systematic plan to isolate any complaint.

Systematic Diagnosis and Repair Procedure

A procedure for conducting a systematic diagnosis includes the following steps:

I. Verify the complaint
II. Define the type of problem
III. Isolate the problem
IV. Test Systematically
V. Verify the cause to the problem
VI. Repair the cause of the problem
VII. Test the repair

I. Verify the Complaint

As with the common point diagnosis sub-procedure covered in Competency F-9, the first step in any diagnosis procedure is to verify the complaint.

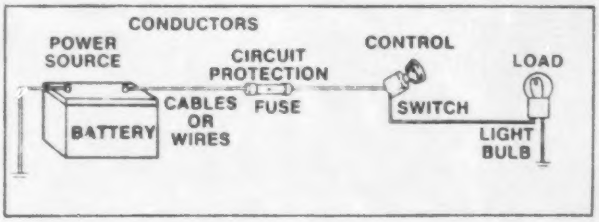
Verifying the complaint is a valuable and necessary step in conducting an electrical diagnosis. Verifying the complaint tells you two important things: first, it shows you that there is, indeed, a problem; second, it permits you to find out much about the problem at first glance.

Most owners do not give accurate and detailed descriptions of their car's problems. If a driver has a problem in his car's lighting system, for instance, he'll usually report something such as, "The lights don't work." This sort of description really doesn't tell you much about the real nature of the problem. So you must verify the problem- check it out- to find out just which light or lights "don't work," which lights do work, and other possibly related symptoms. By thus verifying the problem, you'll actually be well on your way to isolating the problem area. You'll know, for instance, whether the problem is in one, or more, or all of the headlights, taillights, parking lights, sidemarker lights, etc. This gives you a good indication of where to start your diagnosis. If one headlight is out for instance, it's an entirely different problem than if both headlights are out, or if all the lights are out.

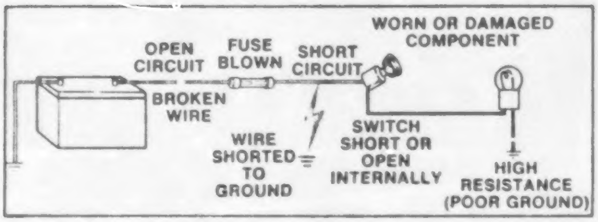
II. Define The Type Of Problem

The second step in a systematic approach to diagnosis and repair is to define the type of problem. As shown below, a typical circuit is composed of a battery, conductors, a fuse, a switch, and a load (in this case a light bulb), and a ground. In this circuit, or any circuit, only four possible things can go wrong and cause a problem (below)

1. An open circuit
2. A short circuit
3. A high resistance
4. A failure of the load


CONDUCTORS
POWER SOURCE
CIRCUIT PROTECTION
CONTROL
LOAD
BATTERY
CABLES OR WIRES
FUSE
SWITCH
LIGHT BULB

TYPICAL CIRCUIT


WORN OR DAMAGED COMPONENT
OPEN CIRCUIT
FUSE BLOWN
SHORT CIRCUIT
BROKEN WIRE
WIRE SHORTED TO GROUND
SWITCH SHORT OR OPEN INTERNALLY
HIGH RESISTANCE (POOR GROUND)

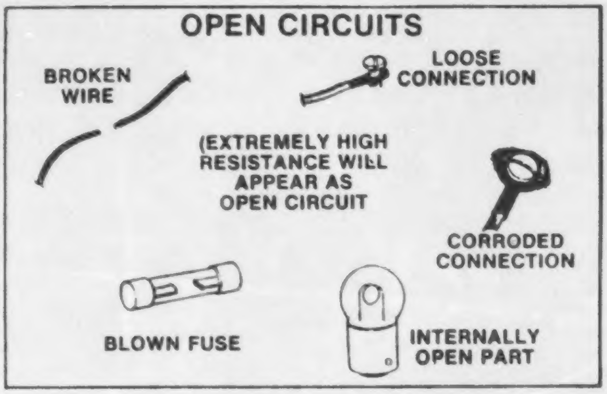
POSSIBLE PROBLEMS IN A TYPICAL CIRCUIT

A worn or damaged load usually shows up as an open, short, or high resistance. Often you can tell at a glance just what the source of the problem is.

Open Circuit

As covered earlier, in competency A-7, power will not flow in an open circuit because there is no complete path for the current from and to the power source. The following are examples of open circuits:

1. Broken or loose conductors or connectors.
2. Blown fuses or popped circuit breakers.
3. Internally open components such as switches, bulbs, etc.
4. Extremely high resistances, which often cause the same symptoms as the other types of open circuits.



TYPICAL EXAMPLES OF OPEN CIRCUITS

Opens due to broken wires are usually caused by accidental damage or vibration. If damaged, the problem is usually visually apparent. Often, however, if the wire is broken by vibration, it is broken within its insulated covering and can only be discovered by testing.

Normal wear will cause certain parts,such as light bulbs, to open internally (burn out). The same normal wear will also cause other parts, such as switches and motors, to become open internally after extended use. If such parts wear out after limited service, however, you might suspect some other cause, such as overloads in the circuit or excessively high voltage.

In diagnosing open circuits, inspect for obvious causes such as cut or kinked wires, frayed insulation, and corroded terminals, and connectors. Corrosion causes a high resistance, and a resistance that is extremely high will often act exactly like an open.

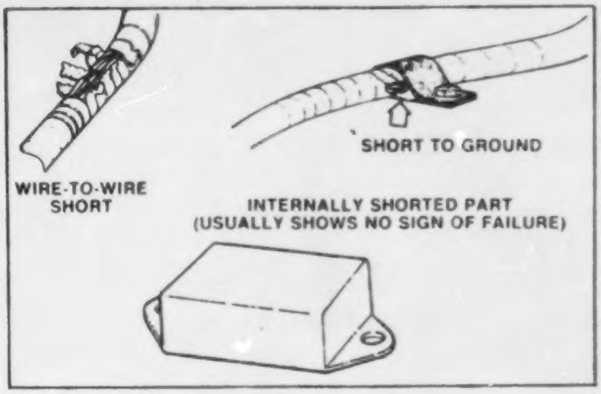
One of the most bothersome types of opens is the intermittent type of open. Intermittence may be caused, for instance, by a wire that has broken within its insulation but still is making contact while the car is stopped. Then, when the car is moving and vibrating, the intermittence occurs. In searching for this type of open, you should wiggle the circuit wiring around with your hand to see if you can cause the open symptom to come and go.

Blown fuses and popped circuit breakers show up as open circuits. These circuit protection devices open because of overloads. You can spot a blown fuse easily by looking at it. A blown fuse or popped circuit breaker is, however, a symptom of a short or overload somewhere in the circuit.

When consicering open circuit problems, you should also consider the effects of opens on simple and complicated circuits. This topic is covered in more detail in Competency F-8, Idenfifying Circuit Feedback.

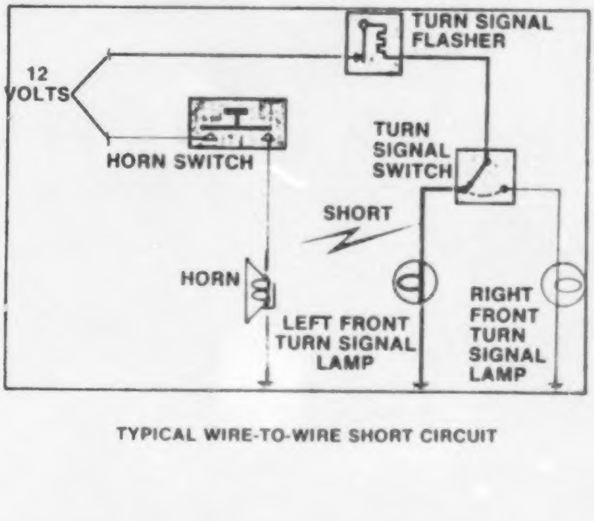
Short Circuit

To repeat what was covered earlier, a short circuit occurs whenever a circuit is completed in a way that was not designed. Short circuits are most noticeable when they create an accidental current path which bypasses the current away from the load or the control device.


WIRE-TO-WIRE SHORT
SHORT TO GROUND
INTERNALLY SHORTED PART (USUALLY SHOWS NO SIGN OF FAILURE)

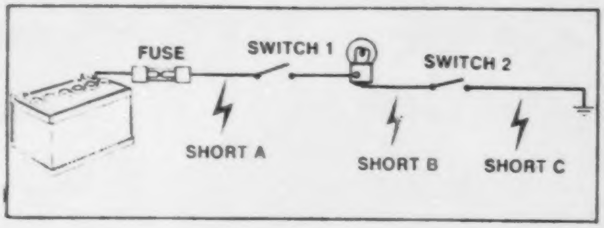
TYPICAL SHORT CIRCUITS

Short circuits, (above), happen whenever a "hot" conductor accidentally makes contact with another conductor or with ground. Parts can also be shorted internally. Depending on the type of short (wire to wire, or hot wire to ground), you'll actually get two different types of symptoms. The wire to wire short often may cause some funny things to happen. The wiring for the turn signals and the horn, for instance, is in the steering column harness. If a certain couple of wires within this harness become shorted together, the horn could sound whenever the turn signal lever was moved. The example below illustrates how this could happen. A short in the steering column harness (or any harness) is usually caused by pinching or crushing the harness, damaging the insulation or adjacent wires. If the two wires shown below make contact the horn will blow intermittently whenever the left turn signal is turned on and the left turn signal will flash whenever the horn button is pressed.


TURN SIGNAL FLASHER
12 VOLTS
HORN SWITCH
TURN SIGNAL SWITCH
SHORT
HORN
LEFT FRONT TURN SIGNAL LAMP
RIGHT FRONT TURN SIGNAL LAMP

TYPICAL WIRE-TO-WIRE SHORT CIRCUIT

A short to ground, depending on where it occurs, will have different effects. If a short to ground occurs at point A in the figure below, the load and both switches will be bypassed. The circuit will be overloaded (zero resistance will cause an extremely high current flow), and the fuse will blow. Obviously, even if the fuse did not blow, the light would not operate even if both switches were closed. Current takes the path of least resistance; very little current, therefore, would flow through the resistance of the load.



EFFECT OF SHORTS IN DIFFERENT SEGMENTS OF A CIRCUIT

If the short occurred at Point B, only switch No. 2 would be bypassed. If switch No. 1 is closed, the light bulb will operate, regardless whether switch No. 2 is opened or closed. Current does flow through the load, and the circuit, therefore, is not overloaded. So, the fuse will not blow. The only thing that happens it that switch No. 2 becomes ineffective and the light bulb operation can only be controlled by switch No. 1.

If a short should occur at point C, nothing out of the ordinary would happen. Only the designed ground is bypassed, but an alternate path to ground is provided by the short. In effect, therefore, there is no apparent problem.

Like open circuits, short circuits are usually caused by accidental damage or wear due to conductors being pinched against sheet metal by clamps or components, fasteners driven through wires, wires routed over sharp metal edges which cut or chafe through insulation, misplaced metal parts which contact uninsulated portions of wires, etc.

Loads may become shorted internally due to extended overloads.

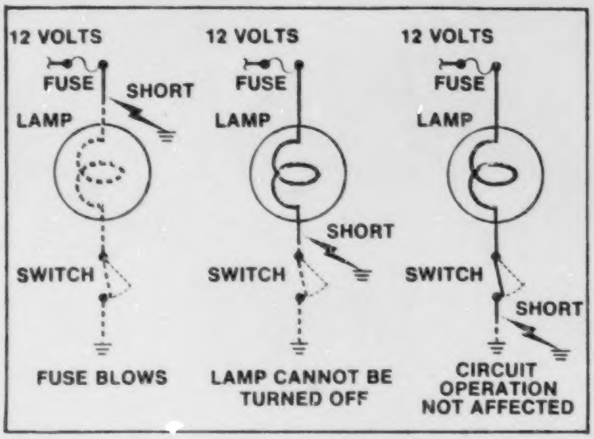
When inspecting for suspected shortcircuits, look for obvious fraying of bare wires. Like intermittent open circuits, intermittent short circuits are the most difficult type to isolate. Use the same technique- wiggling the wires- to see if you can cause the symptoms to come and go.

Also be sure to relate the symptoms of the short circuit to its probable location. As illustrated in the following figure,

- A short between the power source and the load will blow a fuse. (If the circuit is unfused the conductor will overheat,the insulation will melt, and the wire will probably burn in two.)

- If there is a switch between the load and ground (as with engine warning lights), and the short is between the load and the switch, the load will be on constantly.

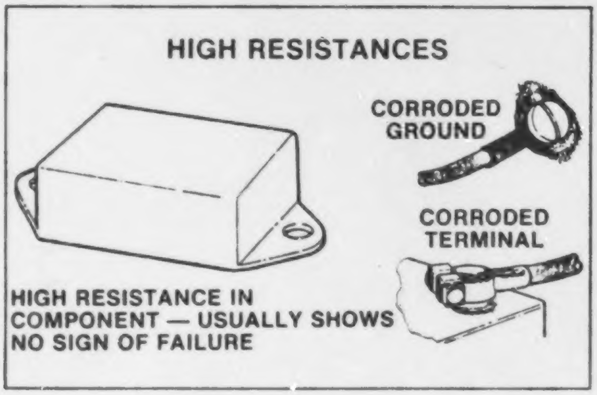
- If the short is between all components and ground, it will have no effect. (In all probability, no problem will be reported.


12 VOLTS
FUSE
SHORT
LAMP
SWITCH
FUSE BLOWS
12 VOLTS
FUSE
LAMP
SHORT
SWITCH
LAMP CANNOT BE TURNED OFF
12 VOLTS
FUSE
LAMP
SWITCH
SHORT
CIRCUIT OPERATION NOT AFFECTED

EFFECT/LOCATION RELATIONSHIP OF SHORT CIRCUITS

High Resistance

A high resistance, in terms of a problem is any resistance in the circuit that is higher than it is designed to be. High resistances often occur due to corrosion, looseness, or inadequate contact area at terminals, connectors, and grounds. High resistances can also occur internally in components.


HIGH RESISTANCES
CORRODED GROUND
CORRODED TERMINAL
HIGH RESISTANCE IN COMPONENT — USUALLY SHOWS NO SIGN OF FAILURE

TYPICAL EXAMPLES OF HIGH RESISTANCES

A high resistance, in effect, creates a load. The extra load in the circuit, in turn, causes the other loads in that circuit to operate at reduced power. Thus, where a high resistance exists, lights will glow dimmer, motors will run slower, etc.

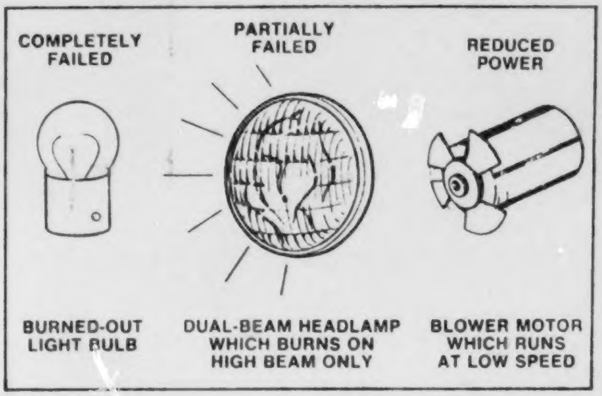
In extreme cases, high resistances may act exactly like open circuits. If a ground terminal becomes excessively corroded, for instance, its resistance (which is designed to be zero) may become so high that none of the loads in the circuit will operate at all.

High resistance at connectors, terminal, and grounds is usually caused by water, road salt, etc., or by the insulating properties of oil, grease, or dirt that gets into the connection. Loads that develop high resistances may do so because of damage, wear, overloads, or vibration. This internal resistance, like all internal damage, is difficult to spot. Corrosion, oil, etc., in connectors, terminals, and grounds are sometimes visible, but often hard to see with the naked eye. This type of high resistance must be checked with test equipment.

Worn or Damaged Load

If the load is worn out or damaged sometimes you can tell so just by looking at it. In a light bulb, you can sometimes see a burnt-out filament or some discoloration. In a motor, you can sometimes see evidence of burning. Often, however, the load shows no evidence of failure. When this occurs, you have to rely on your observation of the entire system, logic, and , particularly, testing to determine that the load has failed. If through observation, you suspect that a part has failed, proceed as follows to make sure:

1. Check that there is power to the component. (See use of jumper wires to provide power, as explained later.)
2. Check that the component is properly grounded.
3. Test systematically to isolate the problem.


COMPLETELY FAILED
PARTIALLY FAILED
REDUCED POWER
BURNED-OUT LIGHT BULB
DUAL-BEAM HEADLAMP WHICH BURNS ON HIGH BEAM ONLY
BLOWER MOTOR WHICH RUNS AT LOW SPEED

TYPICAL WORN OR DAMAGED LOADS

III. Isolate the Problem

After you've verified and defined the type of problem you're faced with, you must next isolate the problem. Isolating the problem involves, essentially, separating the circuit into cimpler circuit.

There are two methods in which to separate a complex circuit. The most obvious, of course, is to physically pull apart connectors , etc.; a time consuming and often difficult task. The second, and simplest method involve the use of wiring diagrams and logic. This is called "common point diagnosis". The advantages of common point diagnosis are:

1. It allows you to separate complex circuits into simpler circuits without physically touching the vechicle, and
2. It allows you to perform some diagnosis mentally, without using, test equipment.

Common Point diagnosis is covered in detail in Competency A-9, "Common Point" Diagnosis Using a Wiring Diagram. The basic procedure is presented below for review.

1. Verify the complaint
2. Locate the component on a wiring diagram
3. Locate common points and common circuits
4. Try the components on common circuits and use logic (to determine problem area)
5. Test the circuit (isolated in the above diagnosis)

With the use of common point diagnosis, you will be able to isolate most electrical problems to one of six areas. These are:

1. Problem at the load
2. Problem between the load and its ground
3. Problem between the load and its first common point with another circuit
4. Problem between the first common point and a second common point
5. Problem between the common point and the power source
6. Problem at the power source

Thus, Common Point diagnosis does not tell you what is exactly wrong with a circuit; but, it does tell you where to test. The actual testing becomes easier and less time consuming since you only have to test a segment of the entire circuit.

IV. Test Systematically

Sometimes problems cannot be isolated or, rather, can be isolated only so far by using Common Point Diagnosis. In these cases, the various types of test equipment at your disposal become invaluable. In order to use the test equipment effectively, however, you often will have to organize your testing systematically and logically.

A. Systematic Approach

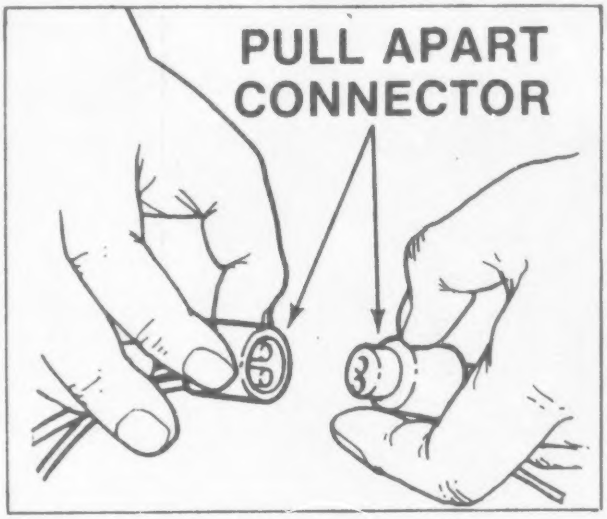
One of the results of the Common Point Diagnosis was the separation of a complicated circuit into six basic segments. Often identifying the problem area, you now know the part of the circuit where you can begin testing. In most automobile circuits, however, a basic circuit section may include numerous sub-sections, separated by connectors and splices. When doing actual testing, you may find the need to separate these segments to gain access to test points and to further isolate the problem.

Separation of Circuits

For testing, circuits can be separated into simpler circuits by either of two methods: separation at connectors and switches, or by cutting and splicing when finished.

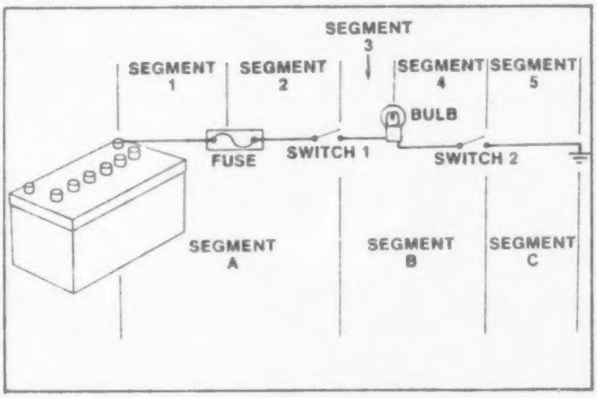
Separation at Connectors and Switches

To simplify a circuit by separating at connector, you [illegible] pull apart the connector to gain access to the connector terminals for testing purposes.


PULL APART CONNECTOR

SEPARATING A CIRCUIT AT A CONNECTOR

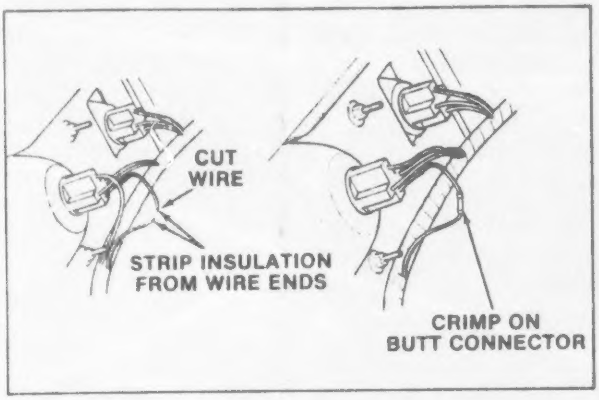
Simpler circuits can also be achieved by opening switches in the circuits. The circuit shown below can be separated into three simpler segments (segments A, B, C) just by opening switch 1 and switch 2. By opening both switches and removing the fuse and bulb as well, the circuit is separated into five segments.


SEGMENT 3
SEGMENT 1
SEGMENT 2
SEGMENT 4
SEGMENT 5
BULB
FUSE
SWITCH 1
SWITCH 2
SEGMENT A
SEGMENT B
SEGMENT C

SEPARATING A CIRCUIT INTO SIMPLER CIRCUITS

Cutting And Splicing

In some areas the circuit can be made more somple only by cutting wires. This method is used as a last resort when the circuit must be made simpler than can be done by opening switches, connectors, etc., or in areas where there are no convenient means of opening the circuit. Once you cut the wire, strip the insulation from the wire ends to attach the test equipment. After testing the circuit, slip a butt connector onto the exposed wire ends and securely crimp on a butt connector. Whichever method you use, the whole purpose is to simplify the circuit to make the most effective use of your test equipment.



CUT AND SPLICE METHOD OF CIRCUIT SEPARATION

Use of Test Equipment

The types and application of test equipment is covered in competencies A-2, A-3, A-4, and A-7, and a review of test methods applicable to the four types of circuit problems is covered in this competencies information sheet #2. Your selection of test equipment and methods will, of course, depend on the type of problem. Typically your testing will progress from simple tests to more complex methods.

B. Logical Approach

Knowing what component or part of a circuit to test may not be enough in an actual test situation.

Generally, if only one component in a system is inoperative, start diagnosis at the component. However, this advice must be tempered by logic. For example, if a power window motor does not operate, do not begin diagnosis of the problem by taking apart the door to get at the motor. To save time, start by checking the power window switch and other more accessible points between the switch and power source. Don't perform the time consuming tasks until previous testing has isolated the problem to the motor itself.

V. Verify the Cause of the Problem

The fifth step in the systematic approach to diagnosis is to validate the cause of the problem. This means that, after you have isolated a problem by using the wiring diagrams and/or test equipment, you test to confirm that, by correcting the condition you have found, you do, in fact, eliminate the original complaint in all modes of operation. Actually, this is merely the first step in repairing the problem.

VI. Repairing the Cause of the Problem

Step number six in the systematic approach is to make the repair. It is assumed that the user of this manual, having validated the cause of the problem can perform such repairs as replacing electrical parts. Repairing wiring calls for some special techniques which are explained in the section on repair. (see Competency A-8)

VII. Testing the Repair

The seventh and final step in the systematic approach to diagnosis and repair is to check that the repair does, indeed, correct the problem. The final checkout should be thorough to avoid the possibility of a comeback. When making the final checkout of the repaired system, be sure to check, not only the area of repair, but also all other possibly related systems. Often, particularly in the case of intermittent problems, a road test may be necessary to assure that the problem does not recur under dynamic conditions.

Summary of the Systematic Approach

The importance of using a logical and systematic approach cannot be over-emphasized. Compared to the diagnosis-by-the-seat-of-your-pants methods used by some technicians, the approach just described will save you much time and effort.

Here is a good example of a haphazard approach that's been taken an untold number of times, often by technicians who consider themselves pretty sharp. When one turn signal lamp goes out, for instance, almost everyone's first instinct is to change the bulb. That's not an approved method of diagnosis and repair, but it's not a bad idea; its's a fast method for light bulbs. But when replacing the bulb doesn't fix the problem, often the next instinct is to replace the flasher, and then to think about the switch. Actually, most of the time, when the lamp isn't burnt out, the fault is a poor ground at the lamp. So you can see how the parts replacement method can lead to wasted time and expense.

Electrical Competencies- Body & Chassis

No. F-10 Perform Systematic Diagnosis and Testing

Information Sheet #2

Testing Methods

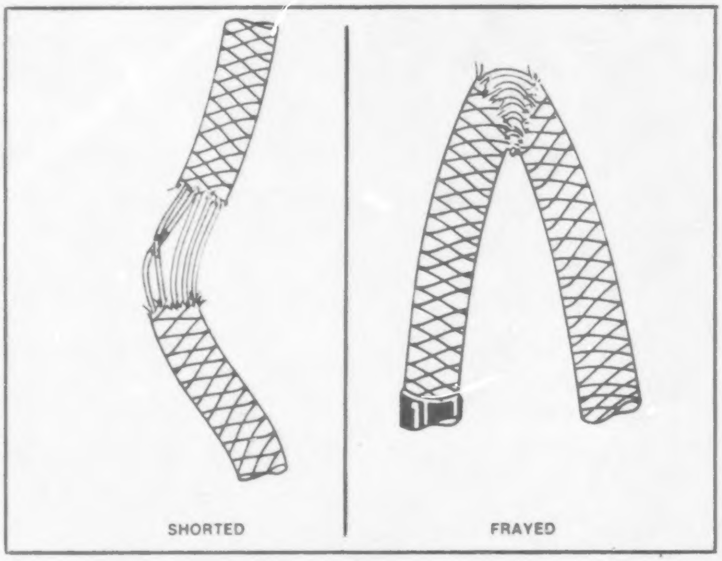
The systematic approach to trouble-shooting requires that you be familiar with some basic testing procedures. The following is a review.

Visual Inspection

Visual inspection before electrical testing is always a good idea, where the wires and components are easily accessibel to the eye. The most common problems that show up from visual inspection are defective connections or damaged wires (below) such as frayed insulation or sharp kinks.

A loose connection can cause intermittent (off and on) operation of the circuit; or can cause the circuit to be open. Breaks in the wires usually open the circuit; shorts drain the power away from the load.

To check whether the wires are causing the problem, move them around cautiously by hand. See if the complaint comes and goes; a sure sign of a short circuit or a bad connection.



DAMAGED WIRES

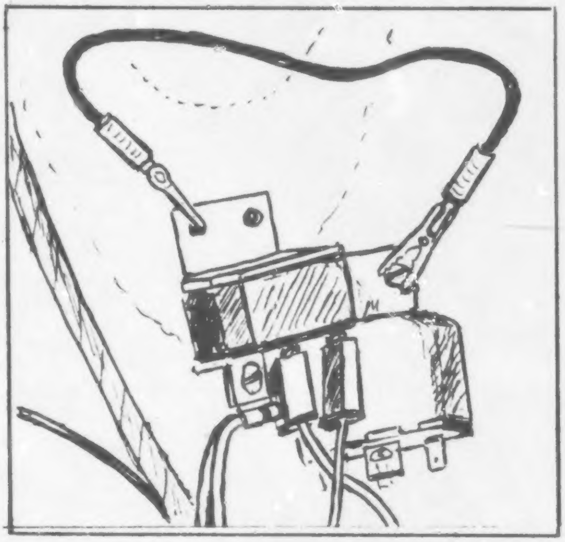
Substitution Testing

Where the trouble symptoms indicate the failure of a component that is easily substituted, replacing the component is often the fastest method of trouble-shooting.

If the "known good" part restores the circuit function, the removed part must be inoperative.

Where repeated failures occur to fuses or bulbs, look for other conditions causing the failure. Fuses fail repeatedly of overloads or short circuits. Light bulbs may fail again and again from vibration or excessive voltage.

For components which must be mounted by other means than their electrical connectors, it's a good practice to simply make the the connections and test the circuit before mounting the part. Then, if the "known good" part doesn't operate, you don't have to remove and replace it again. For example, the power window safety relay (below) can be checked by plugging in and grounding a known-good relay and testing the circuit operation.



SUBSTITUTION TESTING OF POWER
WINDOW SAFETY RELAY

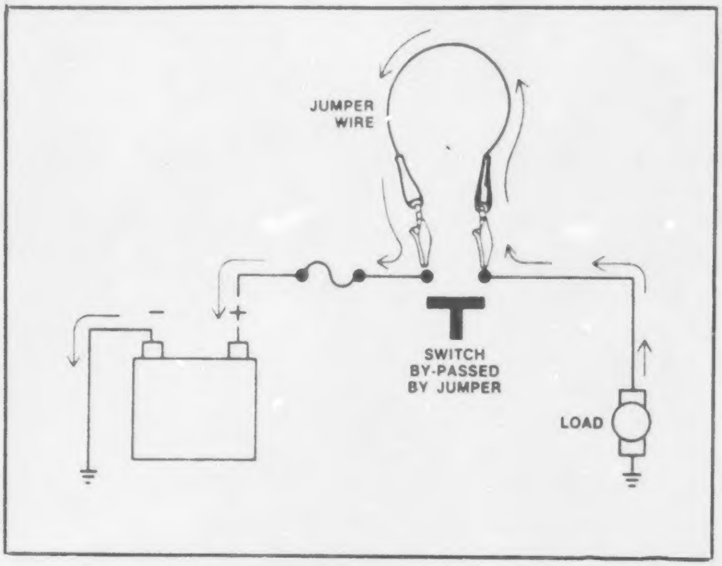
Open Circuit - Jumper Wire & Test Light

The jumper wire can be used to substitute temporarily for components such as switches, fuses, breakers, relays, wires or other low-resistance components suspected of being open. Here is how to make such a test:

1. Connect the jumper wire to by-pass the component or conductor suspected of being open (picture on following page)
2. If the circuit is operative, the removed component is open; if not, the defect is somewhere else.

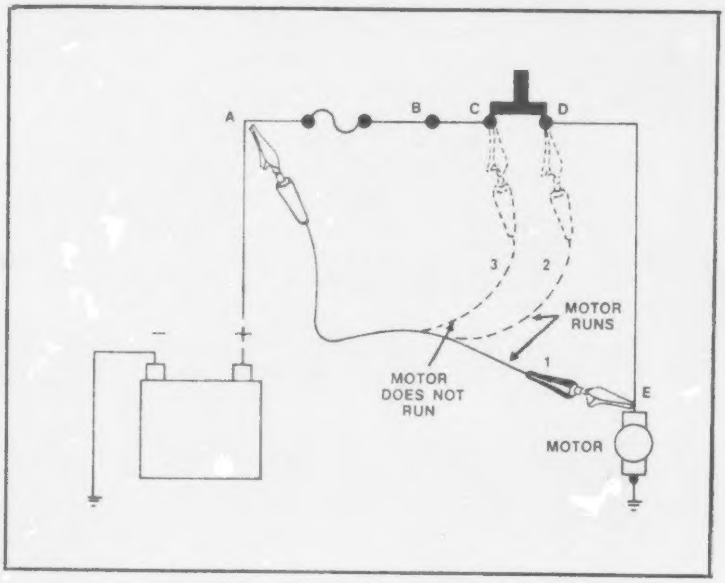
CAUTION: The jumper should never be used to by-pass a resistance component, such as a motor. It would then produce a short to ground and could cause an electric shock or a fire.

It's common practice to "jump" directly from the battery or the starter relay terminal to the hot connection of a load component to see if the component is functional. If the load functions, the open point in the circuit can be found by leaving one terminal of the jumper in place and moving the other to succeeding check points closer to the first.


JUMPER WIRE
SWITCH BY-PASSED BY JUMPER
LOAD
-
+

JUMPER WIRE TEST

In the next figure, one end of the jumper is stationary at point A. With the other end at E, the motor runs; indicating that it is functional and there is continuity from E to ground. The lead then is moved successively back toward the source to find the open place.


A
B
C
D
E
3
2
1
MOTOR RUNS
MOTOR DOES NOT RUN
MOTOR
-
+

ISOLATING OPEN POINT WITH JUMPER

Electrical Competencies- Body & Chassis

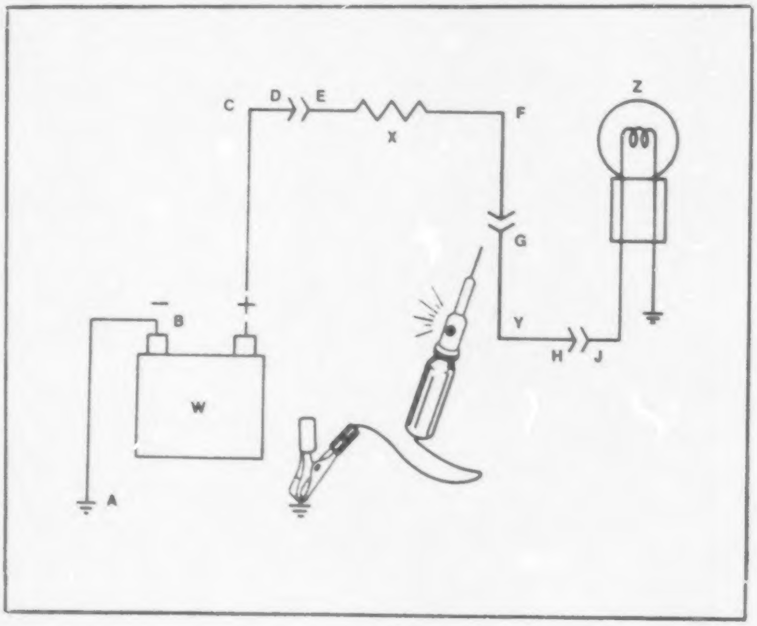
No. F-10 Perform Systematic Diagnosis and Testing

Information Sheet #2
Page 4

When the diagnosis chart, Shop Manual procedure, or your own noodling calls for testing for power, the instrument easiest to use is a 12-volt test lamp (following picture). Tests for power are made at connectors and terminals in feed wires, which sould be "hot". A voltmeter can be used for the power-test if the lamp isn't available; the lamp is easier to use.

By way of review, here is how to use the 12-volt test lamp:

1. Touch or clip one lead from the lamp to ground.
2. Touch the probe to the terminal where you are testing for power.
3. If the light glows, there is power. If it fails to glow, the terminal is not "hot" ; the circuit is open.



12-VOLT TEST LAMP

Short Circuit - Self-powered Test Light

A short circuit is continuity of the unwanted variety. It can be tested for and isolated with a self-powered test lamp.

The following figure (top view) shows a circuit with a short to ground between the switch and the bulb. Every time the switch is closed, the fuse blows.

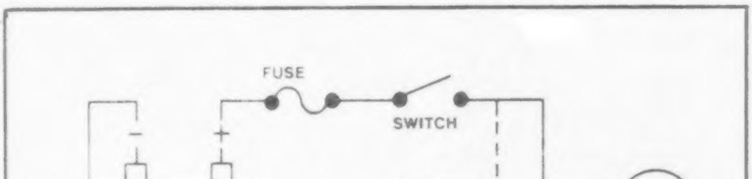
The test for a short is shown in the bottom view. Note that:

1. The circuit is disconnected from power (by removing the fuse) and from ground (by removing the bulb).

2. The test light is connected from the hot wire to ground.

3. When the switch is closed, a circuit is completed by the short to light the test lamp.

The test light could not glow unless a short is present to complete the circuit.
- The short is between the switch and the bulb socket if the light glows only with the switch closed.
- If the light continued to glow with the switch open, the short would have to be between the fuse and the switch. (In that case, fuses would blow with the switch open.)



SHORT CIRCUIT TEST

The following procedure will isolate a short circuit.

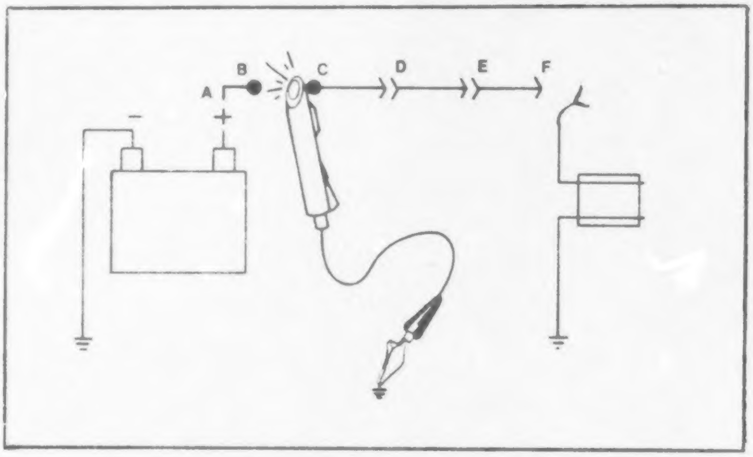
1. Determine the location of all the wire connectors.

2. Remove power and ground from the circuit.

3. Connect one end of the self-powered light to the circuit and the other to ground. If the light glows, the circuit is grounded.

4. Unplug the connector farthest from the light (point F below) and observe if the light still glows. If the light goes out, the short is beyond that connector.

5. Continue opening connectors or switches working toward the test light. When the light goes out, the short is beyond that disconnect and before the next disconnect.



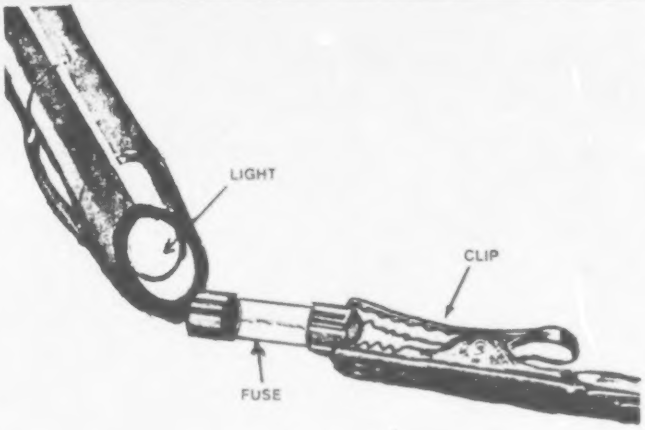
For example, if the test light glows when connector F is separated, but does not glow when connector E is separated, then the wire section E-F is shorted to ground.

More elaborate test equipment has been developed for testing short circuits. These include the "Short Finder" which uses an induction ammeter to locate current flow in a circuit and the Ford developed "Lout test light". Both devices allow the circuit to be energized while the short is being located. (See information sheet #4)

Continuity - Self-powered Test Light

Continuity tests are made with an ohmmeter, or more conveniently with a self-powered test light (below)

To test for continuity, this procedure applies:
1. Be sure to disconnect the part being tested from the circuit.
2. Clip the lead to one terminal and touch the light tip to the other.
3. If the light glows, there is continuity. If not, the component is open.



The test light does not glow, indicating that the fuse is good.

TESTING FOR CONTINUITY

The following picture shows a test of a "normally closed" relay using a self-powered test light to check for continuity. The light glows before the coil is energized, because the points are closed. It goes out when the coil is energized to open the points.

Relays can be tested easily by energizing their coils with a hot jumper wire and checking for continuity across their points.

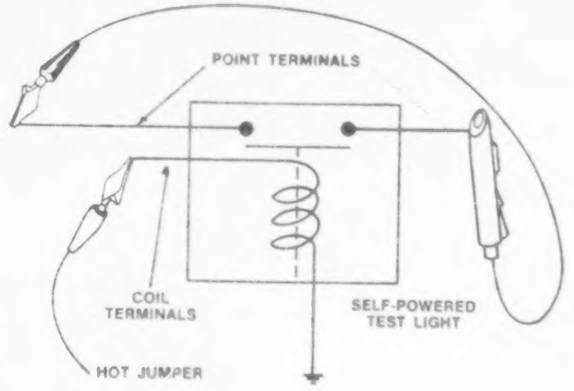


FIGURE 9—TESTING A NORMALLY CLOSED RELAY

Electrical Competencies- Body & Chassis

No. F-10 Perform Systematic Diagnosis and Testing

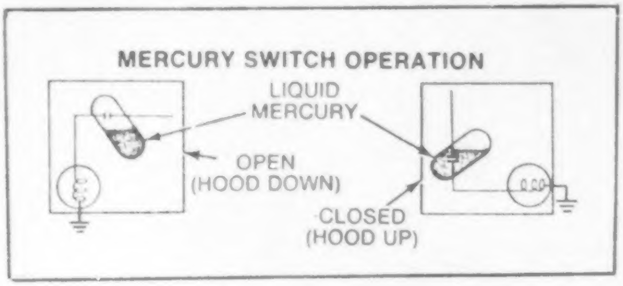
Information Sheet #3

Open Circuit Example Problems

Problem #1- No Hood Lamp

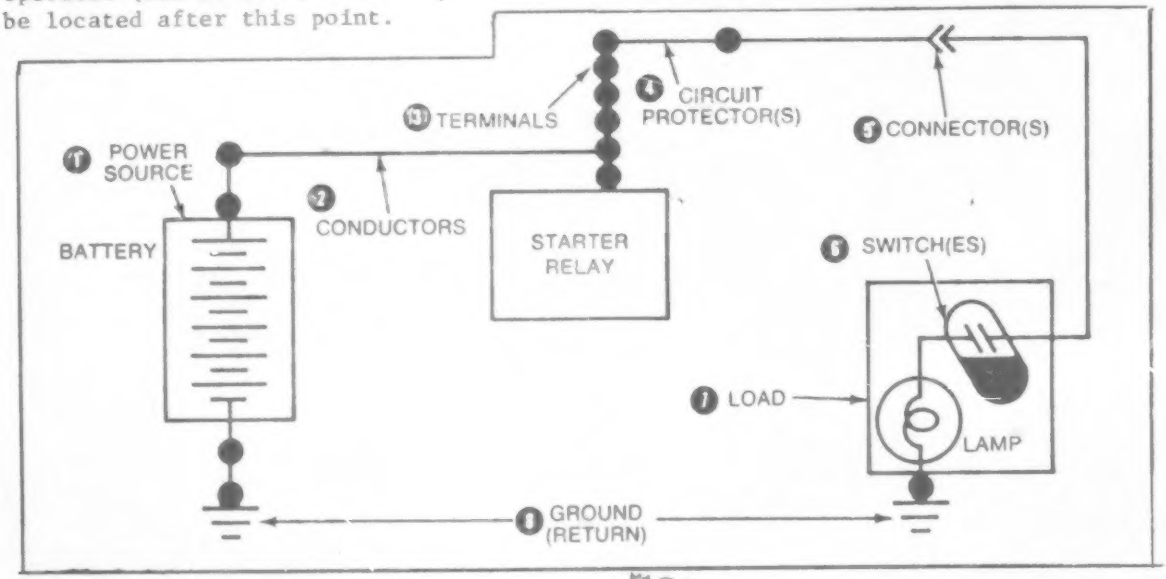
In this problem, the R.O. says simply "no hood lamp". It is illustrated on a Montego, but the circuit is virtually identical on all car lines. To apply our 7-step diagnosis system:

Step 1. Verify the Complaint
To determine that there is a problem open the hood. When the hood is lifted, the column of mercury (a liquid metal) inside the switch should connect the switch contacts and close the circuit. If the light doesn't come on, the circuit is open somewhere.


MERCURY SWITCH OPERATION
LIQUID MERCURY
OPEN (HOOD DOWN)
CLOSED (HOOD UP)

Step 2. Define the Type of Problem
From the results of our operational check, we conclude that some part of the circuit is open. Since light bulbs commonly fail, and this one is very easy to get at, our first check might be substitution with a known good bulb. In this situation, it is a valid test and may correct the problem with a minimum amount of time and effort. A new light bulb is then tried,- still not operation.

Step 3. Isolate the problem
In checking the wiring diagram we find this is a simple circuit. The first common point in the circuit is at the starter relay. If the starter relay operated (and it does) we have power at the terminals and the circuit problem must be located after this point.


① POWER SOURCE
BATTERY
② CONDUCTORS
③ TERMINALS
STARTER RELAY
④ CIRCUIT PROTECTOR(S)
⑤ CONNECTOR(S)
⑥ SWITCH(ES)
⑦ LOAD
LAMP
⑧ GROUND (RETURN)

Since this is the shortest section that we can isolate using common point diagnosis, the actual problem will have to be isolated and pinpointed during testing.

Step 4. Test Systematically
Our first testing step is to determine what testing tools we will use. Since this is an open circuit, we will be looking for a point where power stops. This can be done easily with a test light. Further tests to bypass open circuits can be done with a jumper wire.

The next step to testing, is to separate the circuit into simpler units. To do this we need to transfer our wiring diagram information to the vehicle to locate all parts of the circuit.

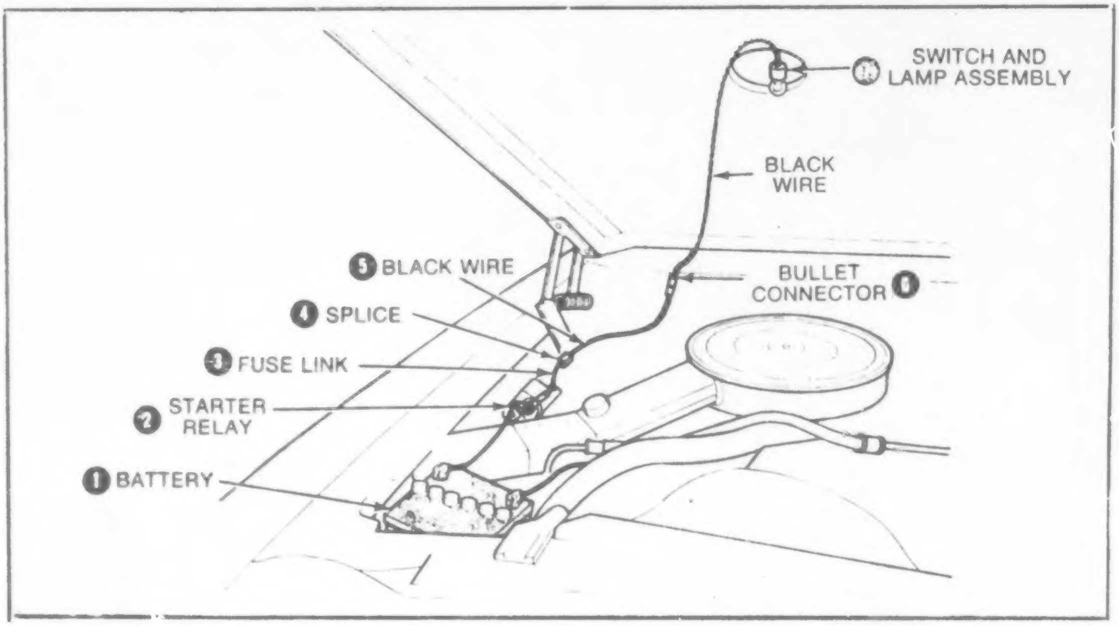
Starting at the battery positive terminal 1, the circuit is through the positive cable to the main feed terminal at the starter relay 2. From there, a fuse link 3 is connected by a molded splice 4 to the hot wire 5, which is black in this circuit.

(On some earlier models, incidentally, a 7.5 amp inline fuse is used in place of the fuse link.)

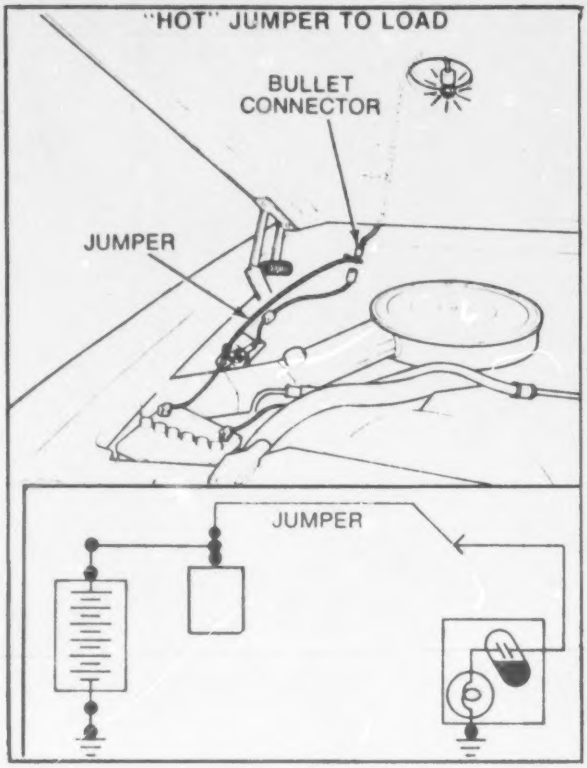
The hot wire continues along the right fender apron and cowl to a bullet connector 6. This connector permits separating the wiring if the hood is removed.

From the bullet connector, the circuit continues through a single black wire, under the hood insulation, to the switch and lamp assembly 7.

The lamp socket is grounded through its mounting bracket to the hood sheet metal. So the chassis completes the ground circuit back to the battery.



An open circuit involving only one load would usually be tested starting at the load and follwoing the circuit back to its power source. In this example, we note that the lamp and switch assembly are bolted to the hood and wired directly into the circuit. Logically the first test point should be a more accessible one. We thus select the bullet connector at the base of the hood.



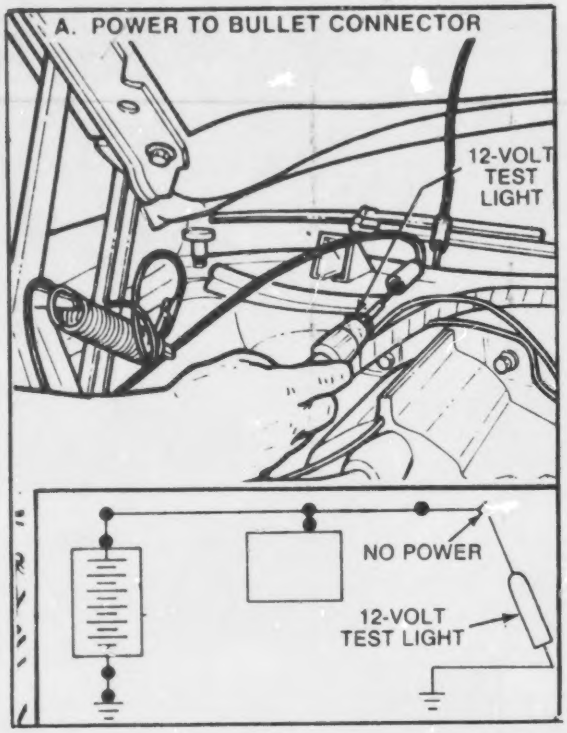
TEST. Open the bullet connector. Clip one end of a jumper wire to the terminal of the hood wiring and the other end to the starter relay main feed terminal.

RESULT. The hood light comes on and stays on.

CONCLUSIONS. The light and its ground are okay; in fact, the circuit is okay beyond the bullet connector. The trouble must be in the part of the circuit we by-passed: from the starter relay up to the bullet connector. We have *isolated* the problem to part of the circuit.

(Of course, if the light *didn't* go on, we'd check the bulb and the ground.)

Now to pinpoint the problem, we'll use the 12-volt test lamp and check for power through the part of the circuit that's open. We'll start at the other half of the bullet connector,



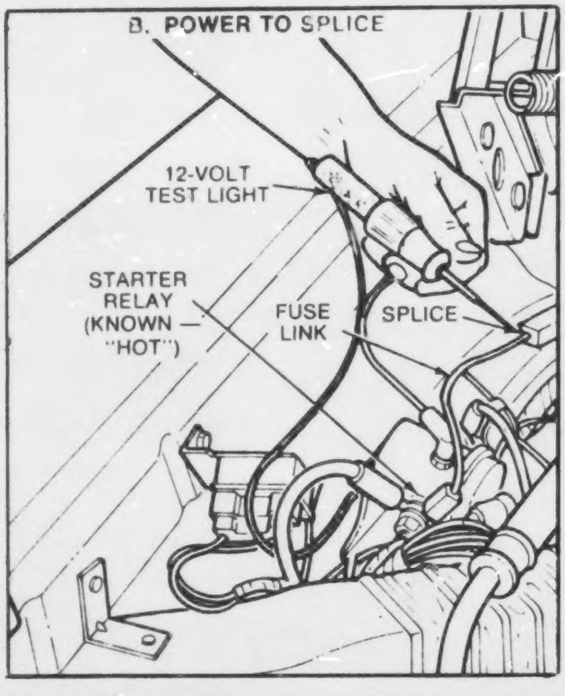
A. POWER TO BULLET CONNECTOR

TEST. Ground the test light lead wire and touch the probe tip to the female wire terminal (socket) of the bullet connector. (If this terminal is hot, a good connection of the two terminals should make the circuit work).

RESULT. No power to the connector. The socket is not hot; the test light doesn't come on.

CONCLUSION. The circuit is open ahead of the connector, but beyond the starter relay terminal.

We'll continue moving toward the power source with the test light, since the entire circuit is out in the open. (If it weren't, we'd test at the most convenient places first.)



B. POWER TO SPLICE

TEST. Insert the test light probe into the insulation at the splice. Be sure it touches the bare wire.

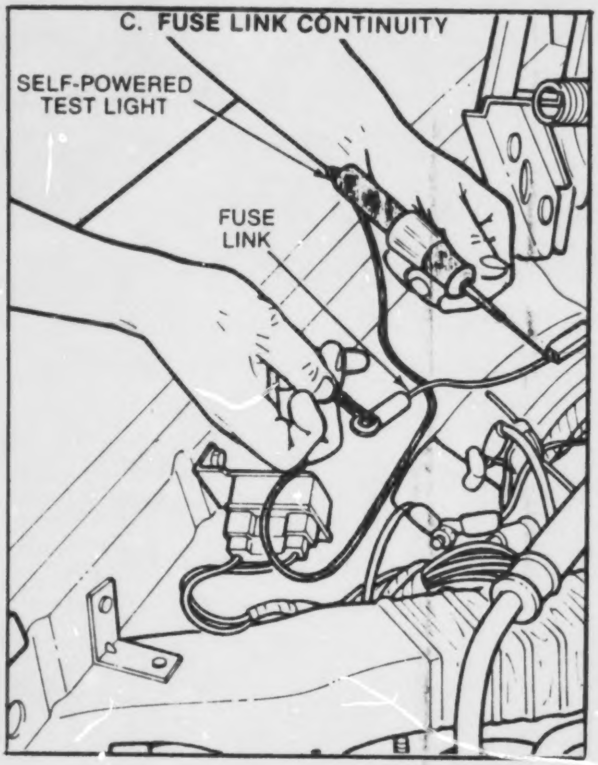
RESULT. No power to the splice.

CONCLUSION. Since we know that the starter relay is hot, the fuse link must be open.

OPEN CIRCUIT TEST PRINCIPLE
If the circuit test "hot" at one point and there is no power at a succeding point, it is open between the two point.

Step 5. Verify the Problem

At this point, we disconnect the battery negative terminal momentarily and remove the fuse link. Then we want to verify that the fuse link is open. (The problem could be a bad connection at the starter relay terminal.)



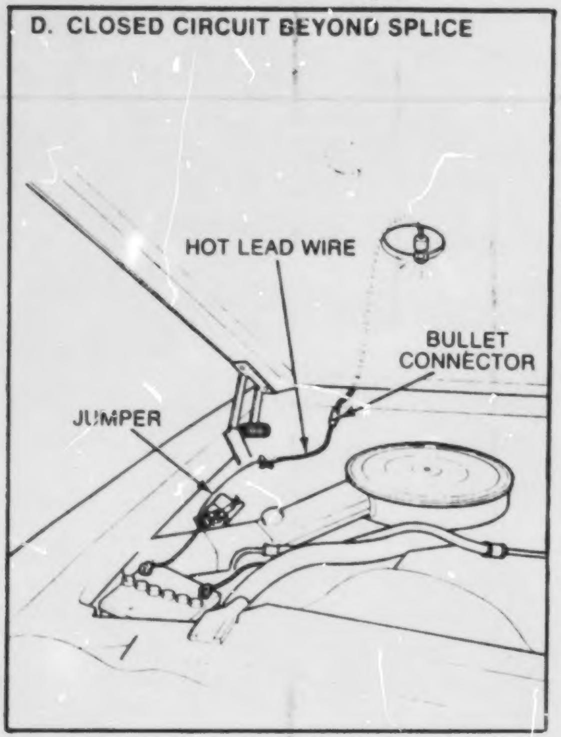
TEST. Connect a self-powered test light between the ends of the fuse link.

RESULTS. The light stays off; the fuse link is open.

CONCLUSION. We have verified the problem, but we haven't determined if it is the only problem, or what caused it to open.
-If there's a short-circuit, the replacement part is going to burn out also.
-If there's another place open in the circuit, a new fuse link won't fix the problem.

So we make just a couple more test before repairing the circuit.

We checked that the circuit was okay beyond the bullet connector earlier. To be certain it's okay up to the connector, snip off the molded splice and strip some insulation from the lead wire. Then get out the jumper again.


D. CLOSED CIRCUIT BEYOND SPLICE

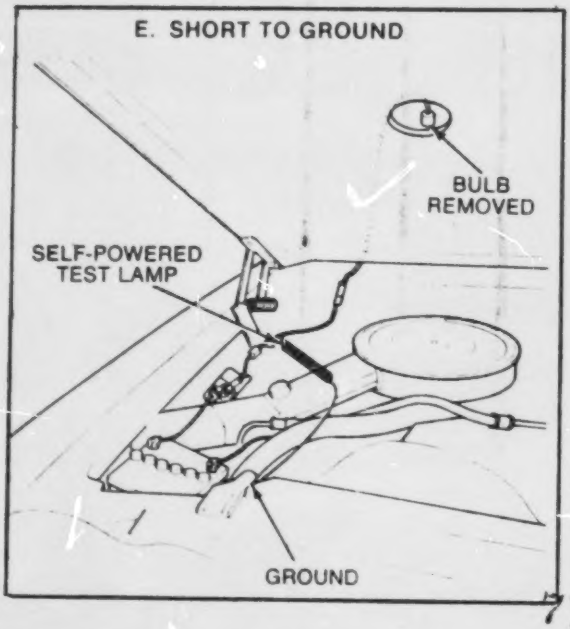
__TEST__. Connect a hot jumper to the circuit lead from the splice; with the bullet connector closed.

__RESULTS__. The hood lamp comes on and stays on.

__CONCLUSION__. The circuit is closed beyond the fuse link.

Why Did The Fuse Link Open?

We still haven't settled how the fuse link got overloaded to cause it to burn out. If there are no signs of blister on the insulation, it may be just that the wires separated under the insulation. But if it's blistered, there's been an overload. That could have been caused by someone grounding the hot terminal in the light socket momentarily, but it's best to be safe and test the circuit for a short to ground.

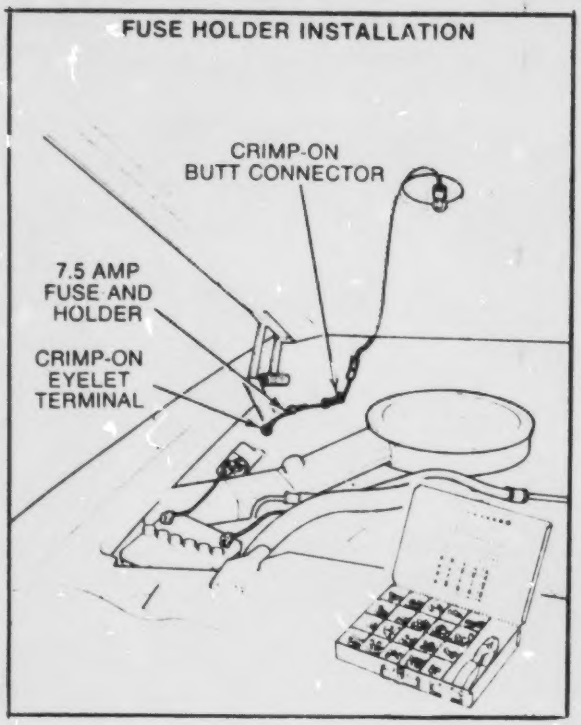

E. SHORT TO GROUND

__TEST__. Connect a self-powered test light between the circuit and ground, with the bulb removed. (The circuit must be isolated from both power and ground for this test). Wiggle the wires, especially behind the hood insulation, in case there's a bare wire touching ground.

__RESULTS__. No continuity to ground. The test light stays off, so we're pretty sure the circuit isn't shorted. We'll complete the repair.

Step 6. Repair

To make the repair, we can splice in a new fusible link, or an in-line fuse holder with a 7.5 amp fuse. The illustration shows the fuse holder, and a handy repair connector kit that no electrical man should be without.



The repair was made in this order:

1. Install the fuse in the holder and test for continuity through the fuse holder and its leads.
2. Install a crimp-on eyelet terminal on one lead of the fuse holder. Be sure it's large enough to fit on the starter relay terminal screw.
3. Connect the other fuse holder lead to the circuit wire with a crimp-on butt connector.
4. Connect the eyelet and other terminals to the starter relay and tighten the nut securely.
5. Install the bulb.
6. Connect the battery negative cable back to the battery after you're done working in the hot circuit.

Step 7. Test the Repair

Always check that the repair has fixed the problem as defined in Step 1. In this case, you should open and close the hood and see that the light goes on and off as it should.

HOOD LIGHT OKAY

REMEMBER THESE OPEN CIRCUIT TESTING PRINCIPLES

BY-PASS: Connect a jumper wire across the part of the circuit suspected of being open; or "jump" power directly to the load. If the circuit operates, it's open in the segment you by-passed.

POWER TESTS: Test for power along the hot circuit with a 12-volt test light. Where you have power at one point and not at the next, the circuit is open between them.

CONTINUITY TEST: Verify that a component or lead is open with a self-powered test light _after_ you disconnect it from the circuit. _Don't_ replace a component when your only problem is a bad connection!

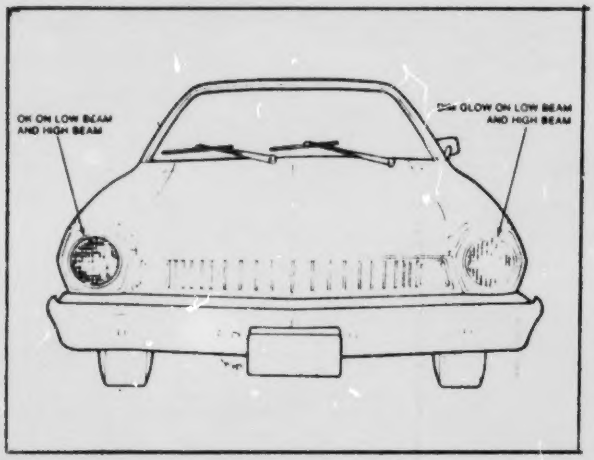
Problem #2- Left Headlamp Out

This problem occured on a Pinto, but can happen in any headlight circuit. The repair order said: "fix the headlights." It might just as easily have said "replace the left sealed beam" if the service advisor fancied himself a diagnostician. It's another example of how proper diagnosis pays off in getting the job done right the first time.

Step 1. Verify the Complaint

Driving into the stall, the technician determined the problem by turning on the headlight switch and hitting the dimmer switch. The right sealed beam threw a light against the wall on both high beam and low beam. The left sealed beam appeared out.

Step 2. Define the Type of Problem



Leaving the headlamp switch on, the technician looked at the left sealed beam up close. He saw a faint orange glow on both the high and low beam positions of the dimmer switch.

This is a common problem, and it's easy to miss the faint glow. You could easily conclude that a new sealed beam will fix the problem- and be dead wrong!

What Makes a Bulb Dim?

There are three most common causes of a bulb operating dimly (or motor running slowly or a horn beeping weakly or any other load component doing only a partial job). In the order of likelihood, they are:

1. The ground is bad (poorly connected), or the ground is open and the load is grounding through some other load operating in parallel with it (see F-8 Identify Circuit Feedback)
2. There is a poor connection somewhere in the hot circuit which is "starving" the load of the electricity it needs to operate fully. (see information sheet #5 in this unit)
3. The load component itself is faulty.

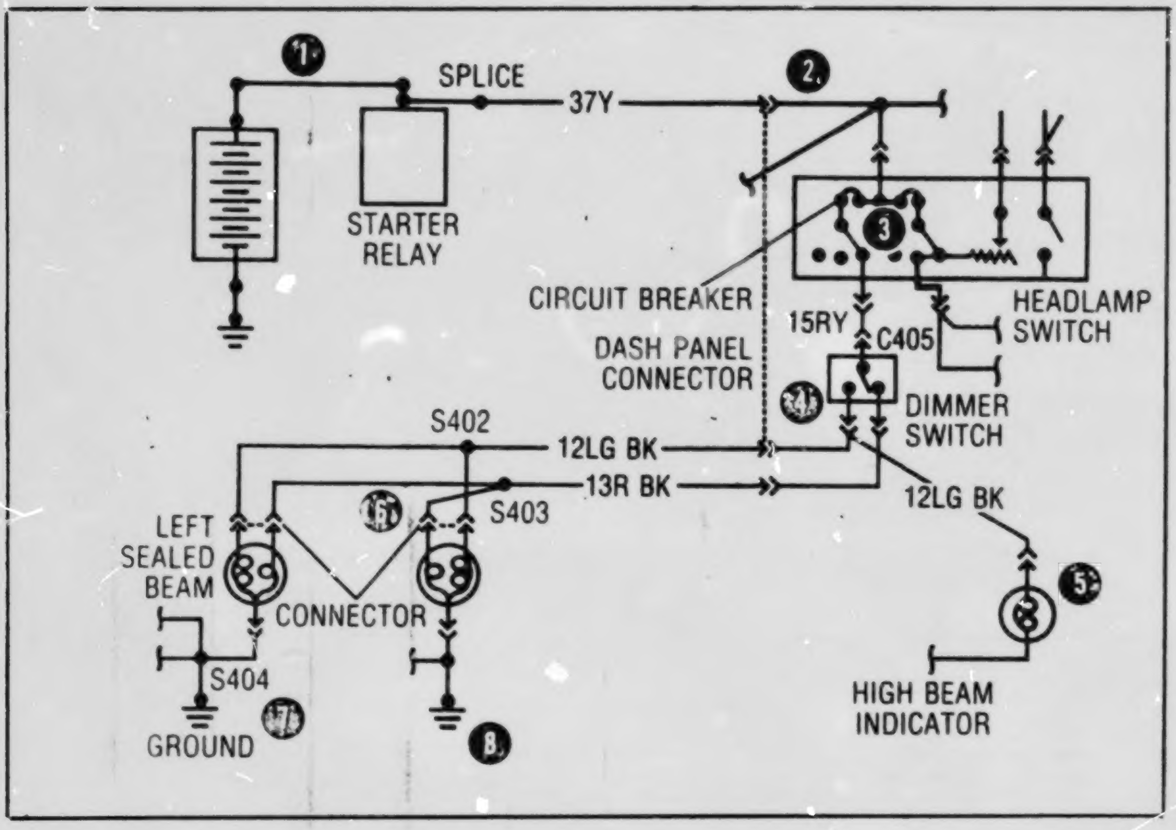
There are other more exotic causes we'll deal with later. For now, let's see how open-circuit testing will diagnose the most frequent causes.

Step 3. Isolate the Problem

Our first step to isolate the problem is to obtain a wiring diagram for the Pinto we are working on. (see following illustration)

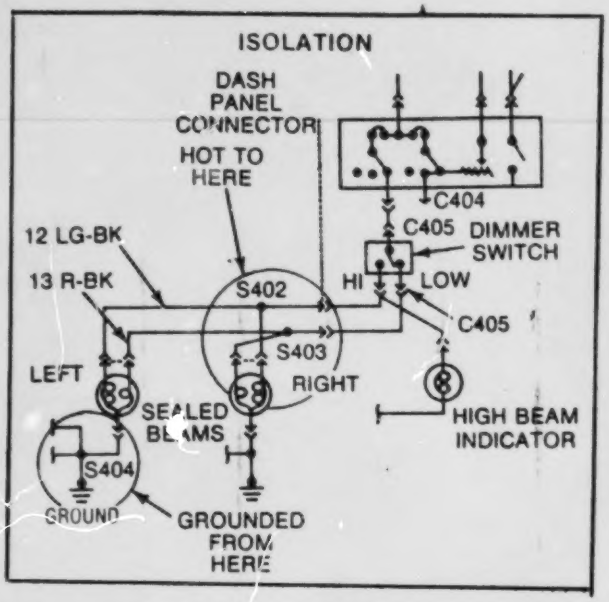
The next step is to locate the component (left sealed beam) on the wiring diagram.

Next, we can trace the circuits. Beginning with the ground circuit, we leave the connector at the back of the headlamp and follow a wire to splice S404. Splice S405 has several other ground circuits joining. It is a "common point" ground connection for the left parking, and marker lights.


1
SPLICE
37Y
2
STARTER RELAY
3
CIRCUIT BREAKER
HEADLAMP SWITCH
15RY
C405
DASH PANEL CONNECTOR
4
DIMMER SWITCH
S402
12LG BK
13R BK
12LG BK
6
S403
LEFT SEALED BEAM
CONNECTOR
5
S404
GROUND
7
8
HIGH BEAM INDICATOR

Tracing the feed circuit, we start with the left side connector and follow a light green wire with black stripe to splice S402. Splice S402 has a branch circuit which leads to the right side sealed beam. This makes splice S402 a first "common point" on this side of the headlight circuit (high beam).

Tracing the low beam feed circuit, we return to the sealed beam component and follow a red with black striped wire to splice S403. Splice S403 has a branch circuit which leads to the low beam side of the right side sealed beam unit. This makes S403 a first "common point" on the low beam side of the headlight circuit.


ISOLATION
DASH PANEL CONNECTOR
HOT TO HERE
C404
C405
DIMMER SWITCH
12 LG-BK
13 R-BK
S402
HI
LOW
C405
S403
LEFT
RIGHT
SEALED BEAMS
HIGH BEAM INDICATOR
S404
GROUND
GROUNDED FROM HERE

Logical Conclusions

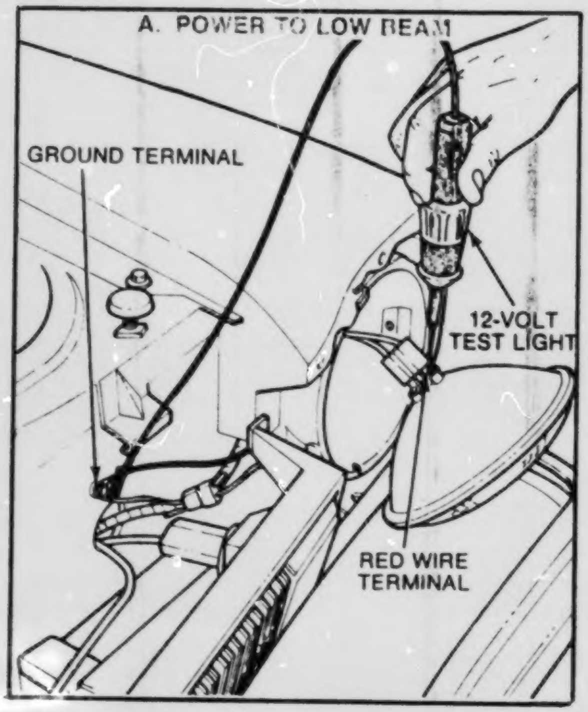
Common point diagnosis is a big help in this problem.

1. Because both the high and low beams work on the right side, we know that the circuit is hot up to splices S-402 and S-403.
2. We look at the parking lamp and find it is okay. That tells us the ground circuit is okay from S-404 to the ground terminal.

The trouble is somewhere in the area marked in red; between the "okay" common points.

Step 4. Test Systematically

Now it's necessary to get at the terminals on the sealed beam. On the car illustrated, we have to pull the rim and free the sealed beam. On others, you can get to the connector easily with the hood up.

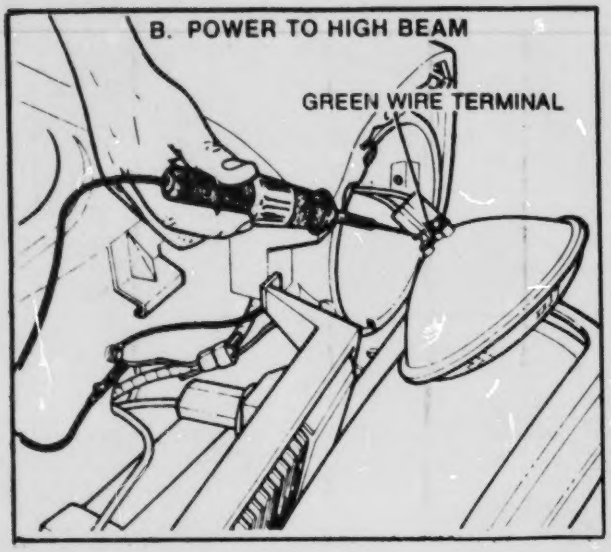

A. POWER TO LOW BEAM
GROUND TERMINAL
12-VOLT TEST LIGHT
RED WIRE TERMINAL

TEST A. Clip the lead of a 12-volt test light to the ground and check for power at the low beam (red wire) terminal of the sealed beam. The dimmer switch must be on low beam, of course.

RESULTS. The test light glows brightly.

CONCLUSION. Circuit 12 is okay up to the sealed beam.

(If the test lamp was dim, we'd suspect a bad connection. Since it's bright, we conclude no problem up to this point.)

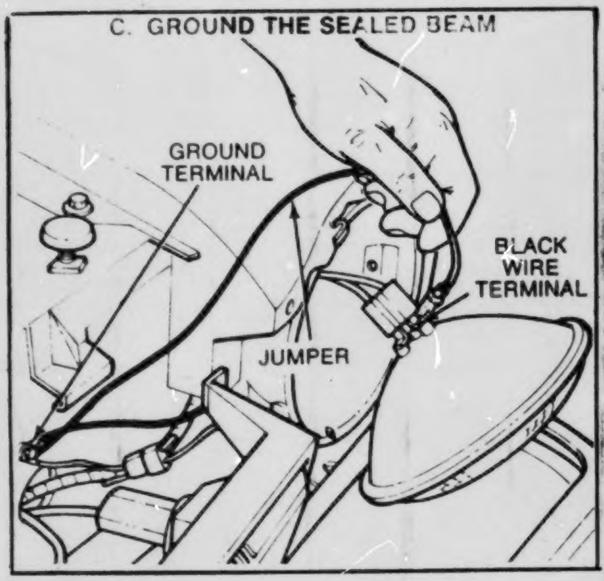

B. POWER TO HIGH BEAM
GREEN WIRE TERMINAL

TEST B. Kick the dimmer switch to high beams and test for power at the green wire terminal.

RESULTS. The test lamp glows brightly.

CONCLUSION. Both power circuits are okay up to the sealed beam. The problme has to be a bad ground or a bad sealed beam.

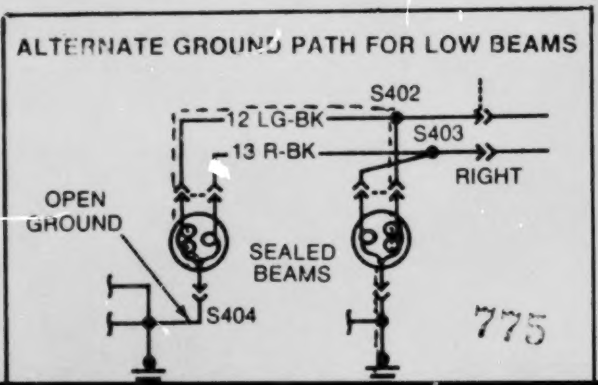
Obviously, it's a lot easier to check the ground than to go get a new sealed beam. So...


C. GROUND THE SEALED BEAM
GROUND TERMINAL
BLACK WIRE TERMINAL
JUMPER

TEST C. Connect a jumper wire from the b[illegible]k wire terminal on the sealed beam to ground.

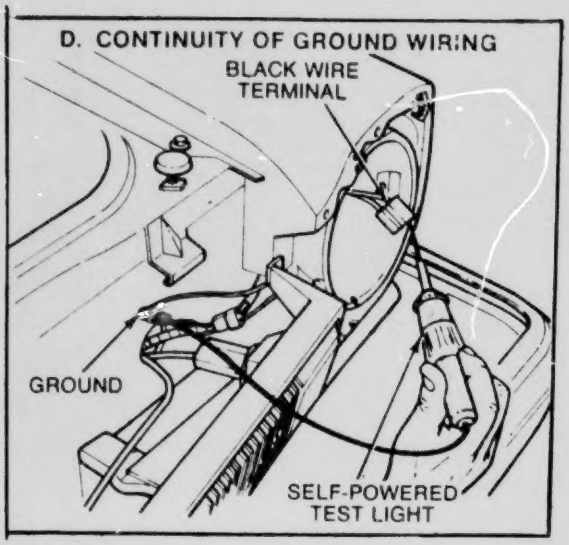
RESULTS. The sealed beam works perfectly; on both high and low beam.

CONCLUSION. The ground wire connection is bad or open between the black wire terminal and splice S-404.


ALTERNATE GROUND PATH FOR LOW BEAMS
S402
12 LG-BK
13 R-BK
S403
RIGHT
OPEN GROUND
SEALED BEAMS
S404

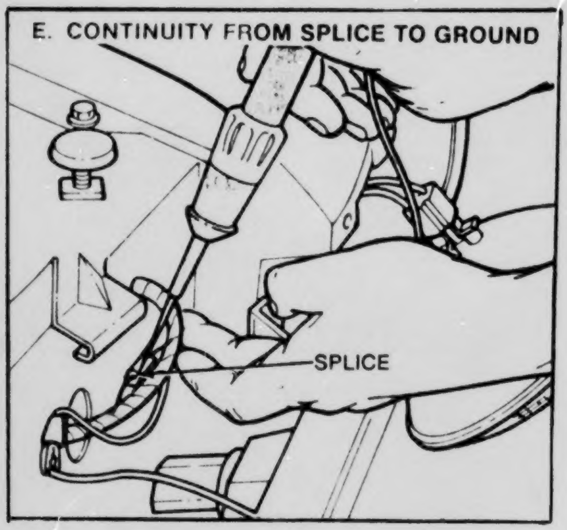
ABOUT THAT DIM GLOW...
The headlamp will glow dimly with a bad or open ground, because there is a ground path through the opposite beam. For inst[illegible]ce, on low beam, the ground path is through t[illegible] high beam filament, then through wire 12 to the right hand beam and through its high beam filament to ground.

The filament in series offer enough resistance to prevent the low beam from operating at full brightness. (see Competency F-8, We have determined that the left headlamp ground is open somewhere between the sealed beam and the ground splice. To try to pinpoint it, we will use a self-powered test light with a probe tip for a couple of continuity checks. We'll turn the headlamp switch off to isolate the circuit from power. Also, we will unplug the sealed beam so that the "alternate" ground path is out of the circuit.


D. CONTINUITY OF GROUND WIRING
BLACK WIRE TERMINAL
GROUND
SELF-POWERED TEST LIGHT

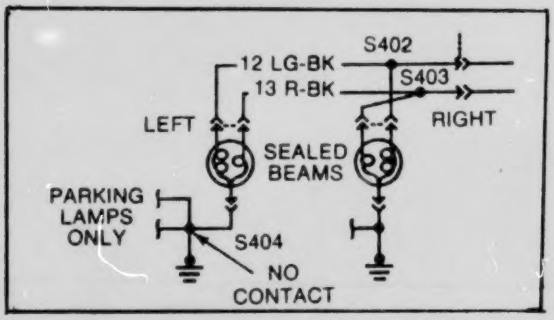
TEST D. Clip the lead of the test light to the ground terminal and touch the probe to the black wire terminal of the headlamp connector. Also insert the probe tip into the wire near the connector.

RESULTS. No continuity to ground. (If the test light went on, we'd have pinpointed the problem to the connector terminal.)


E. CONTINUITY FROM SPLICE TO GROUND
SPLICE

TEST E. Insert the tester probe into the headlamp ground wire where it enters the splice.

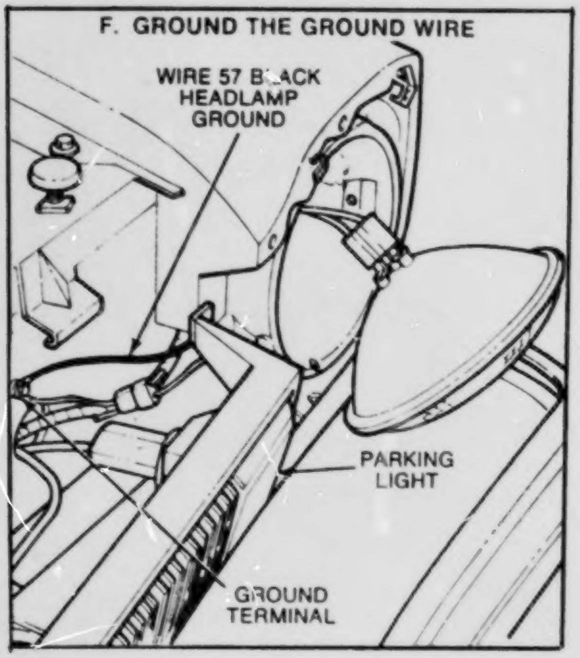
RESULTS. No continuity to ground.


S402
12 LG-BK
13 R-BK
S403
LEFT
RIGHT
SEALED BEAMS
PARKING LAMPS ONLY
S404
NO CONTACT

CONCLUSION: The headlamp ground wire is not making contact within the splice. (If it were, the tester would light; since we know there is continuity from the splice to ground.)

We have pinpointed the problem. Let's verify it.

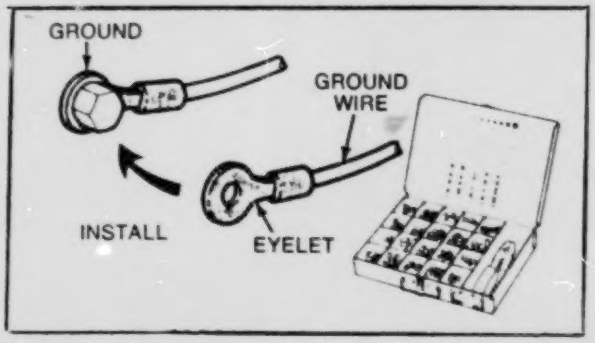
Step 5. Verify The Cause Of The Problem
For the final diagnosis, turn the headlamp switch back on. And clip the headlamp ground wire from the splice with side-cutters.


F. GROUND THE GROUND WIRE
WIRE 57 BLACK HEADLAMP GROUND
PARKING LIGHT
GROUND TERMINAL

TEST F. Touch the bare end of the wire to ground.

RESULTS. The headlamp works okay.

Step 6. Repair
To repair the circuit, install a crimp-on eyelet on the ground wire and attach it to the ground terminal screw.


GROUND
GROUND WIRE
INSTALL
EYELET

Step 7. Test the Repair
Then try the headlights one final time on high beam and low beam. They work okay... problem corrected by systematic testing and a very simple fix.

SYSTEMATIC TESTING SAVES "FACE"

This problem was chosen for an example because about 40% of electrical failures are caused by poor grounds. Systematic testing avoided replacing the load component unnecessarily, which could cause "egg on the face" when you have to take the part back to the parts department.

DON'T FORGET...
For a circuit to operate, three things are necessary:

1. There must be power to the load.
2. The load component must be okay.
3. The circuit must have continuity from the load to ground.

Be sure that your systematic diagnosis covers all three factors.

Electrical Competencies- Body & Chassis

No. F-10 Perform Systematic Diagnosis and Testing

Information Sheet #4
Page 1

Short Circuit Example Problems

Problem # 1 - A/C AND TURN SIGNAL FUSE BLOWS

On a 1975 Monarch or Granada repair order, this problem is stated: "A/C and turn signal fuse keeps blowing. Check electrical circuits." A blown fuse, remember, indicates an overload in the circuit, and we'll proceed to check it for a short to ground.

Step 1. Verify the complaint

To determine this problem, we first pull the fuse and look at it to see if the filament is melted. Or, we can test for power at the fuse terminals with a 12-volt test light. If both terminals are hot, the fuse is good. If only one terminal is hot, the fuse is blown. In this case, a visual check was enough proof that the fuse was indeed "blown."

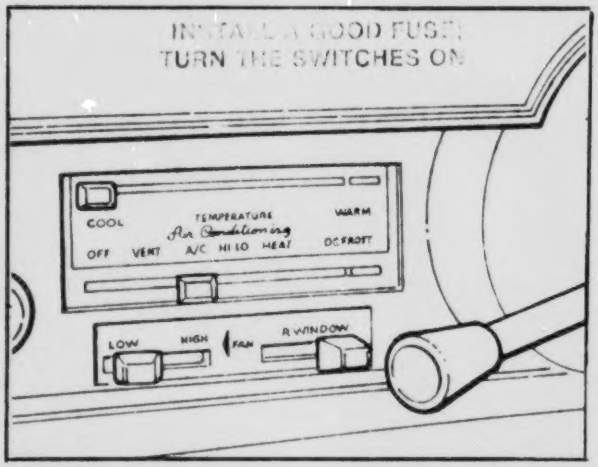
Step 2. Define the type of problem

At this point, you may suspect a short. In order to define the type of problem adequately, however, you need to answer the following questions.

1. Is the problem a short or is the fuse overloaded (wrong fuse?)

2. If the problem is a short, is it intermittent or constant?

3. If the problem is a short, which circuit is causing the problem - turn signal or air conditioner?



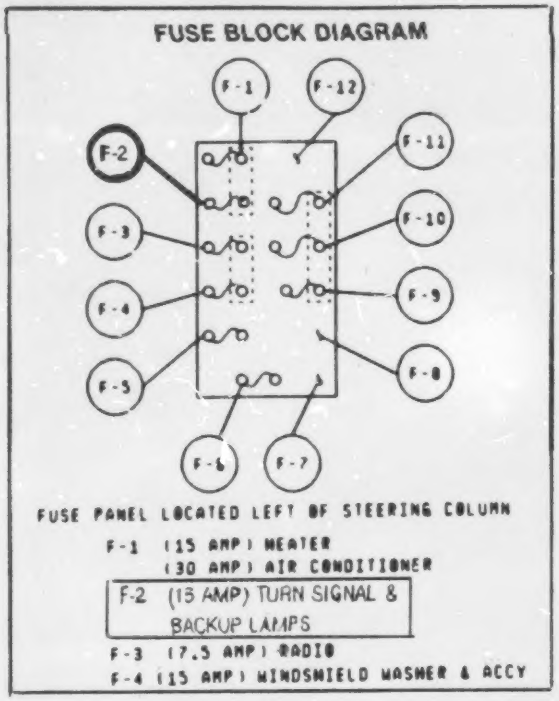
Your next step could be to install a new fuse of the same size and check system operation. With a good fuse in the circuit, operate the A/C controls and the turn signals, one at a time. If either circuit "blows" the fuse, the trouble is in that circuit.

In this case, the A/C clutch applied and the blower ran, and the turn signals operated okay. Either the short is intermittent, or there's something else fed from this fuse. There is also the possibility of an incorrect fuse size.

In order to answer your question, you will have to have more information.

Our information requires the use of a fuse chart. At this time, you do not have to consult a wiring diagram, although it is one source. The fuse chart can also be found in a shop manual or in the car owners manual.

Information Sheet #4
Page 2


FUSE BLOCK DIAGRAM
F-1
F-12
F-2
F-11
F-3
F-10
F-4
F-9
F-5
F-8
F-6
F-7
FUSE PANEL LOCATED LEFT OF STEERING COLUMN
F-1 (15 AMP) HEATER
(30 AMP) AIR CONDITIONER
F-2 (15 AMP) TURN SIGNAL &
BACKUP LAMPS
F-3 (7.5 AMP) RADIO
F-4 (15 AMP) WINDSHIELD WASHER & ACCY

We located this chart on the first page of the wiring diagram. The first item to note is fuse size. In this problem, the fuse size is correct. This eliminates a possible overload failure due to a wrong size (too small) fuse.

We can also note that the fuse also supplies the backup lamp circuit.

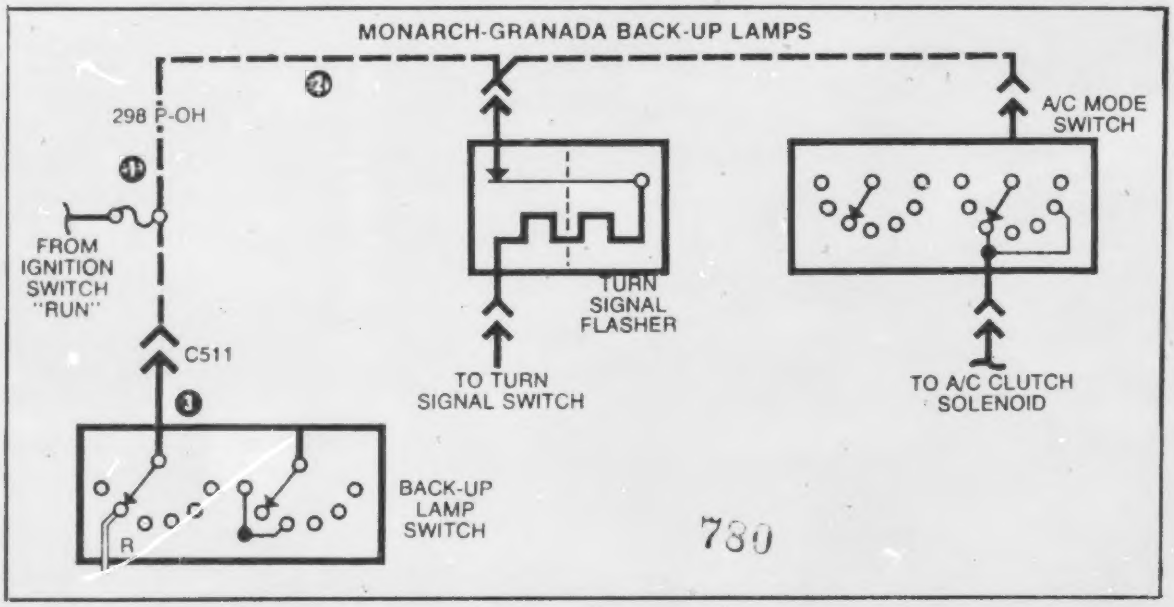
In this case, we shift the transmission selector to reverse to turn on the back-up lamps. The A/C clutch disengages and the turn signals stop. The overload or short is in the back-up light circuit.

The problem: A short circuit on high overload in the backup lamp circuit.

Step 3. Isolate the problem

Our use of a common point diagnosis method is still valid in cases with a short circuit. Typically we look for a common point at the circuit protector and work our way toward the components in each common circuit. We "discovered" the first common point for this circuit during Step 2. The common circuits at the fuse are (1) the turn signal, and (2) the backup lamps.

In order to identify the backup lamp circuit in our example, we will have to consult a wiring diagram. The diagram section below shows the power feed circuits.


MONARCH-GRANADA BACK-UP LAMPS
298 P-OH
FROM IGNITION SWITCH "RUN"
C511
TO TURN SIGNAL SWITCH
TURN SIGNAL FLASHER
A/C MODE SWITCH
TO A/C CLUTCH SOLENOID
BACK-UP LAMP SWITCH
R

1. The fuse is "hot" when the ignition switch is in the run position.

2. There are two branches of wire 298 P-OH from the fuse. One branch connects power to the turn signal flasher, and continues to the A/C mode switch. These are the circuits that went "dead" when the buse blew.

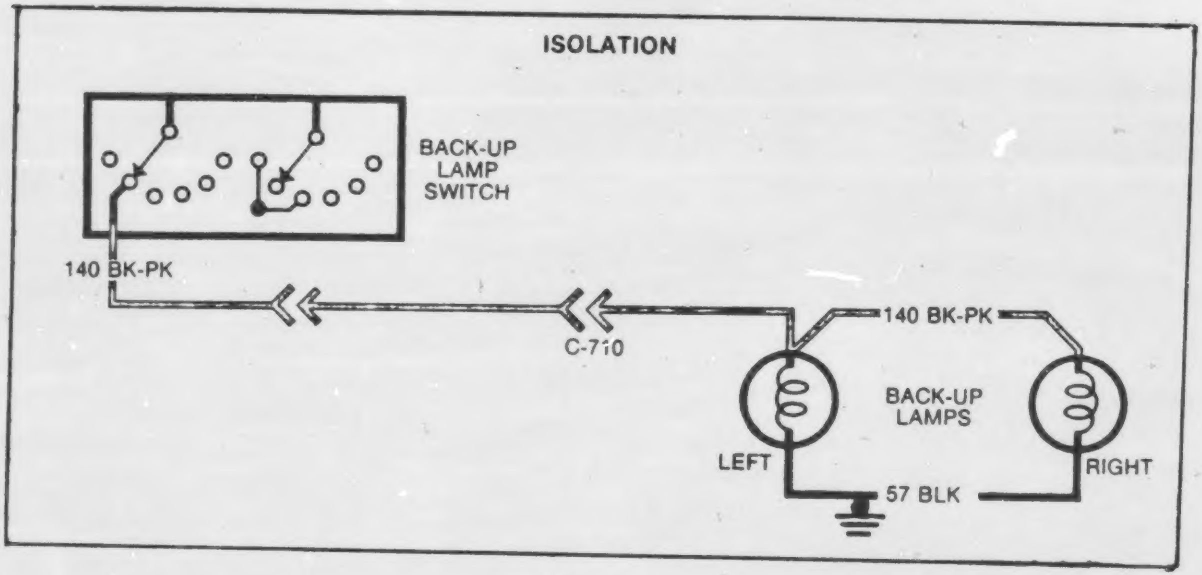
3. The other branch of wire 298 goes through connector C-511 to the back-up lamp switch, which is located on the steering column for column shift cars.

Note that examining the wiring diagram gives us a second common point at the turn signal flasher connector. The common circuit (3) is the air conditioning clutch.

Trying the common circuits would be our next step in common point diagnosis. It was this check which told us that the backup lamp circuit was at fault.

Use Logic for Isolation

Using logic, we have already eliminated a good part of our circuit by discounting the turn signal and A/C circuits. Since the fuse doesn't blow until the backup lights are activated, we can now eliminate the circuit leading up to the switch. If this circuit were at fault the fuse would "blow" as soon as it was installed. Thus, save for the backup lamp switch itself, we have eliminated all of the circuit shown above. The problem is now isolated to the backup lamp switch and its feed circuit (wire 140) to the lamps (below).



4. With the shift selector in R (reverse), power continues via wire 140 to the rear lamps. Wire 140 is joined at two connectors: C-511 which carried power in and C-710, which is the main connector for the rear wiring harness.

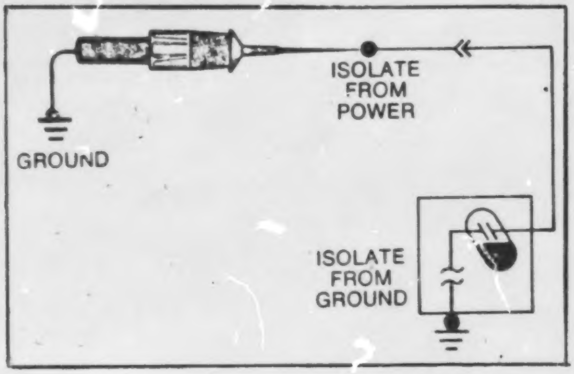
5. Wire 140 is connected directly to the left back-up lamp socket. From there, it also continues in the harness across the rear of the luggage compartment to the right hand lamp.

6. The harness at the rear also contains a ground wire 57 BLK from all the rear lamps. It is grounded to the sheet metal at the rear of the trunk.

Tracing the circuit above gives use no further "clues" as to the cause of the problem. It does give us information on connectors and splice locations, however, which will be valuable when conducting our systematic testing.

Step 4. Test Systematically

Our test procedure will be physically isolate the circuit from the power source and ground and connect a self-powered test light. A review of the procedure is below.

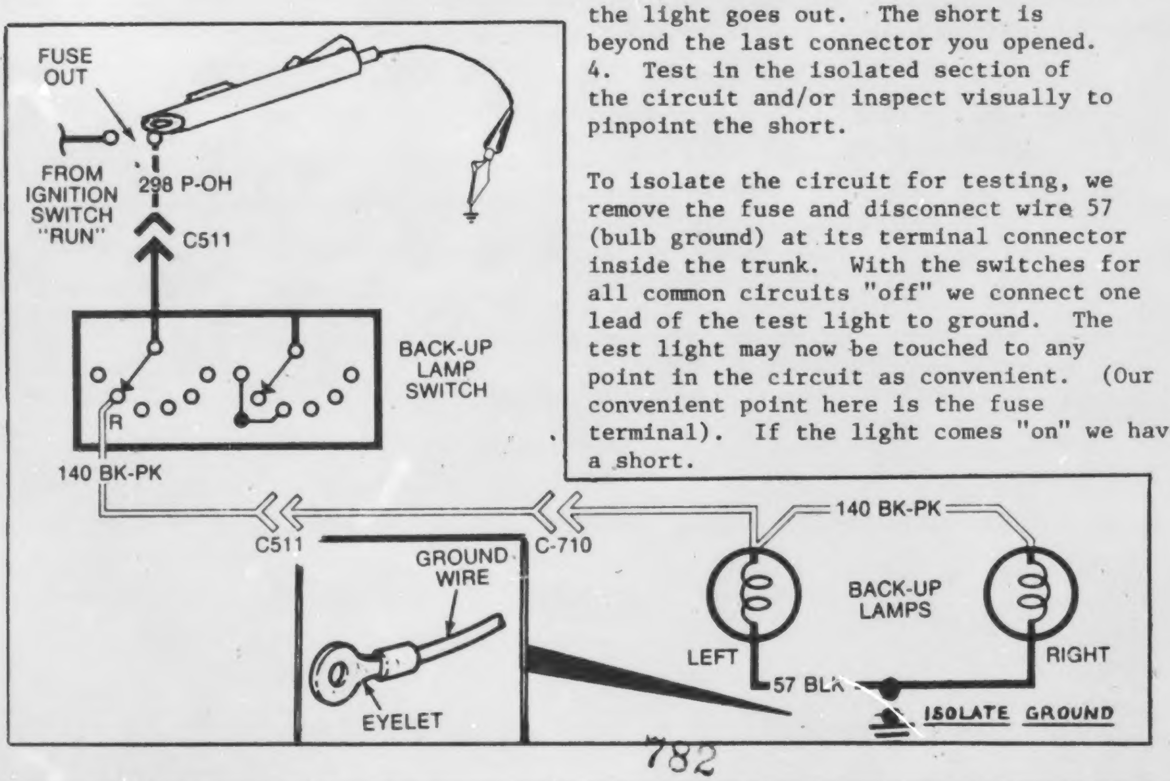

ISOLATE
FROM
POWER
GROUND
ISOLATE
FROM
GROUND

Diagnosing with Self-Powered Test Light

To diagnose a short to ground with the self-powered test light:

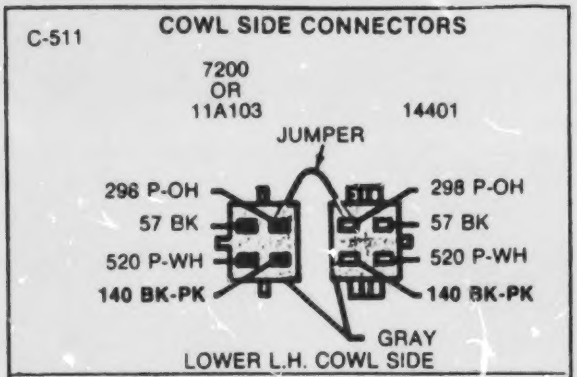
1. Isolate the circuit from power and ground. (For instance, remove the fuse and the bulb or bulb ground).
2. Connect the test light between the circuit and ground at any convenient test point. The light will glow if the circuit is grounded.
3. Open connectors one at a time until the light goes out. The short is beyond the last connector you opened.
4. Test in the isolated section of the circuit and/or inspect visually to pinpoint the short.

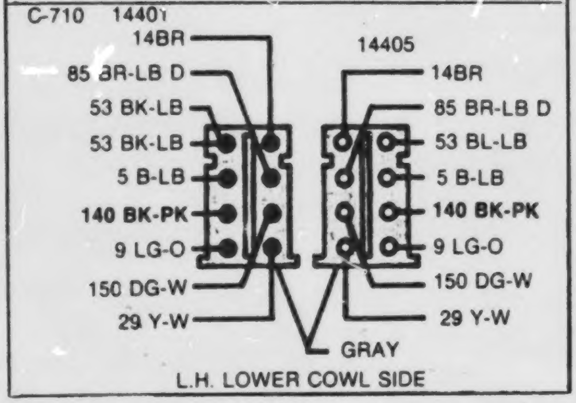
To isolate the circuit for testing, we remove the fuse and disconnect wire 57 (bulb ground) at its terminal connector inside the trunk. With the switches for all common circuits "off" we connect one lead of the test light to ground. The test light may now be touched to any point in the circuit as convenient. (Our convenient point here is the fuse terminal). If the light comes "on" we have a short.


FUSE
OUT
FROM
IGNITION
SWITCH
"RUN"
298 P-OH
C511
BACK-UP
LAMP
SWITCH
R
140 BK-PK
C511
C-710
GROUND
WIRE
EYELET
140 BK-PK
BACK-UP
LAMPS
LEFT
RIGHT
57 BLK
ISOLATE GROUND

Looking at the Wiring Diagrams Book, we find the diagrams shown for the two connectors of wire 140. Both are located at the lower left cowl side, and both are gray.

We have a choice whether it's easier to pull the kick pad or the protective cover in the trunk. We'll start behind the kick pad.


C-511
COWL SIDE CONNECTORS
7200
OR
11A103
14401
JUMPER
298 P-OH
57 BK
520 P-WH
140 BK-PK
298 P-OH
57 BK
520 P-WH
140 BK-PK
GRAY
LOWER L.H. COWL SIDE

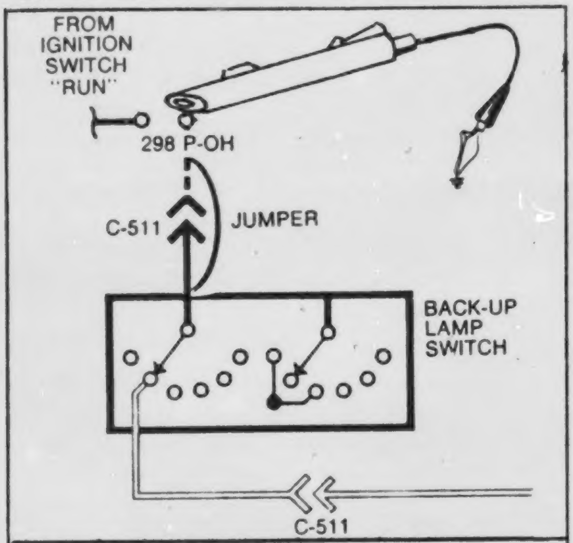

C-710
14401
14BR
85 BR-LB D
53 BK-LB
53 BK-LB
5 B-LB
140 BK-PK
9 LG-O
150 DG-W
29 Y-W
14405
14BR
85 BR-LB D
53 BL-LB
5 B-LB
140 BK-PK
9 LG-O
150 DG-W
29 Y-W
GRAY
L.H. LOWER COWL SIDE

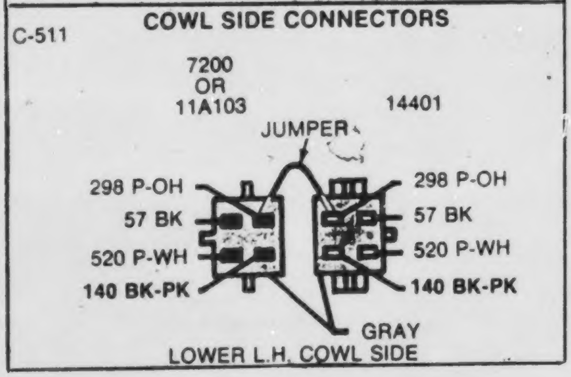
Separate the cowl side connectors one at a time. We'll begin with connector C-511.

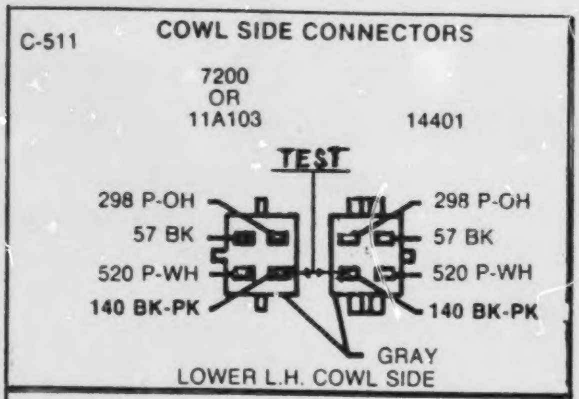
Test A. Separating connector C-511 isolates the switch from both the power and the load circuits. If we wish to retain our test point at the fuse terminal, we'll have to connect a jumper wire between the terminals of wire 298. Otherwise the circuit won't be continuous through the switch. Probe test light to fuse terminal.

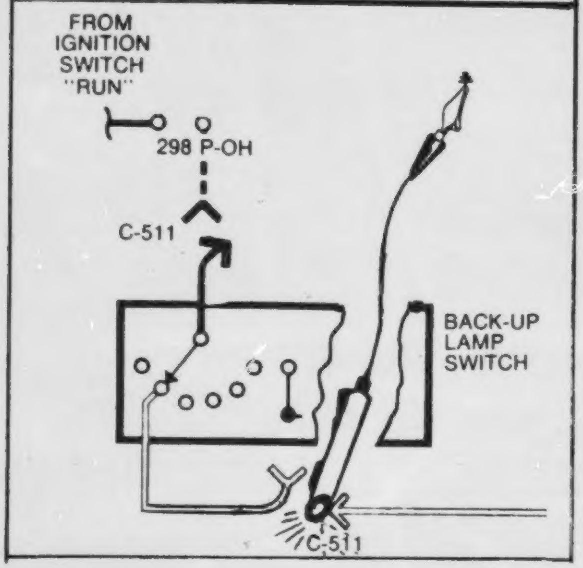
RESULTS. With the connector open and jumper in place, the test light stays out.

CONCLUSION. The short is not in the part of the circuit up to C-511. It must be in the area beyond. Otherwise the tester would have continued to light with C-511 open.


FROM
IGNITION
SWITCH
"RUN"
298 P-OH
C-511
JUMPER
BACK-UP
LAMP
SWITCH
C-511


C-511
COWL SIDE CONNECTORS
7200
OR
11A103
14401
JUMPER
298 P-OH
57 BK
520 P-WH
140 BK-PK
298 P-OH
57 BK
520 P-WH
140 BK-PK
GRAY
LOWER L.H. COWL SIDE

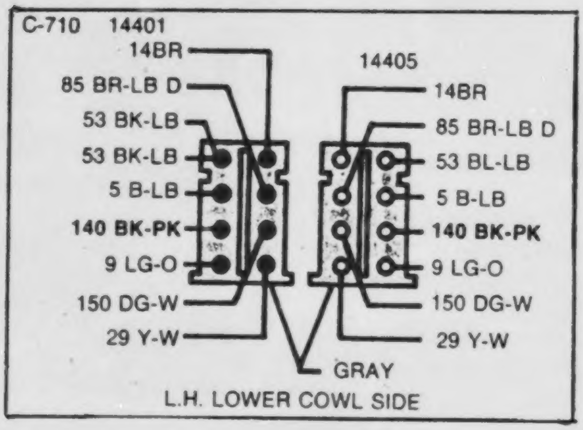

C-511
COWL SIDE CONNECTORS
7200
OR
11A103
14401
TEST
298 P-OH
57 BK
520 P-WH
140 BK-PK
298 P-OH
57 BK
520 P-WH
140 BK-PK
GRAY
LOWER L.H. COWL SIDE


FROM
IGNITION
SWITCH
"RUN"
298 P-OH
C-511
BACK-UP
LAMP
SWITCH
C-511

Test A1, (alternate). An alternate test procedure would involve moving our test light from the fuse terminal directly to the connector C-511. Separating the connector will "split" the circuit into an isolated switch and an isolated load circuit. Probe terminal 140 in the switch side of the connector and in the circuit side of the protector. (Note: the circuit side leads to C-710.)

RESULTS. Test light remains out on the switch side of the connector. Test light comes "on" when probed to the circuit side of the connector

CONCLUSION. The short is not in the part of the circuit up to C-511. It must be in the area beyond. Otherwise the tester would have continued to light when probed to the switch side of the connector


C-710
14401
14BR
85 BR-LB D
53 BK-LB
53 BK-LB
5 B-LB
140 BK-PK
9 LG-O
150 DG-W
29 Y-W
14405
14BR
85 BR-LB D
53 BL-LB
5 B-LB
140 BK-PK
9 LG-O
150 DG-W
29 Y-W
GRAY
L.H. LOWER COWL SIDE

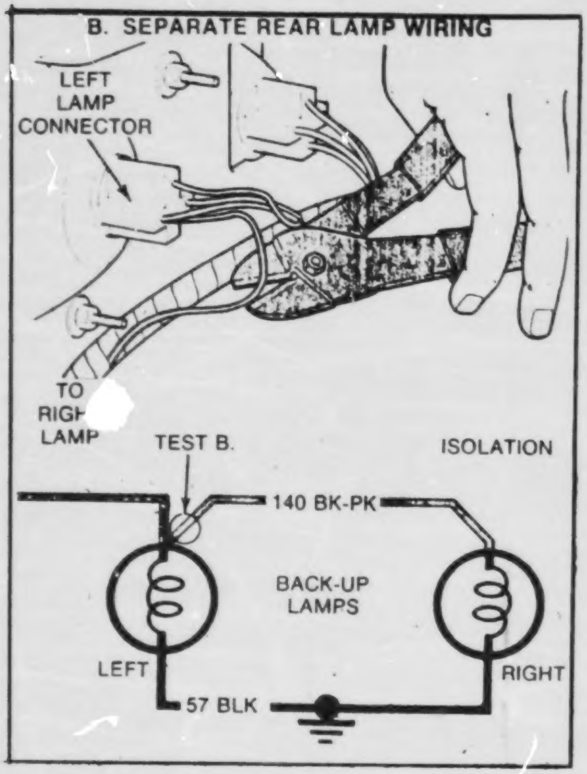
Test B. Separate Connector C-710. Probe test light to fuse terminal. (We can also probe our test light to each side of the connector as in Test A1.)

RESULTS. Test light remains "off" when probed to fuse terminal

CONCLUSION. The short is not in the circuit up to connector C-710. It must be in the area beyond. Otherwise the test light would have continued to light with C-710 open.

The next easiest place to test, then, is in the trunk. We'll open the trunk and remove the protective cover to expose the rear harness.

With the harness exposed, we locate wire 140, black with pink stripes, at the left rear lamp. We don't have a connector here, but a pair of side-cutters make an effective quick disconnect.

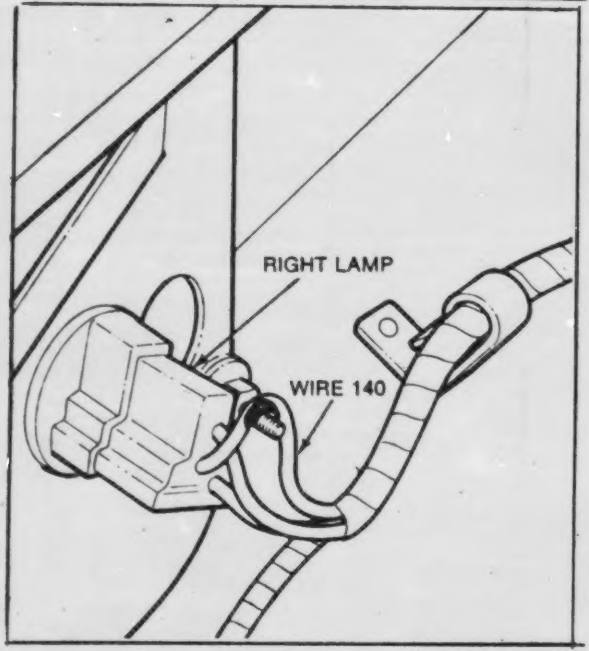

B. SEPARATE REAR LAMP WIRING
LEFT
LAMP
CONNECTOR
TO
RIGH
LAMP
TEST B.
ISOLATION
140 BK-PK
BACK-UP
LAMPS
LEFT
RIGHT
57 BLK

Test C. Snip the wire from the left lamp that leads to the right lamp

RESULTS. The tester goes dead and the left back-up lamp comes on.

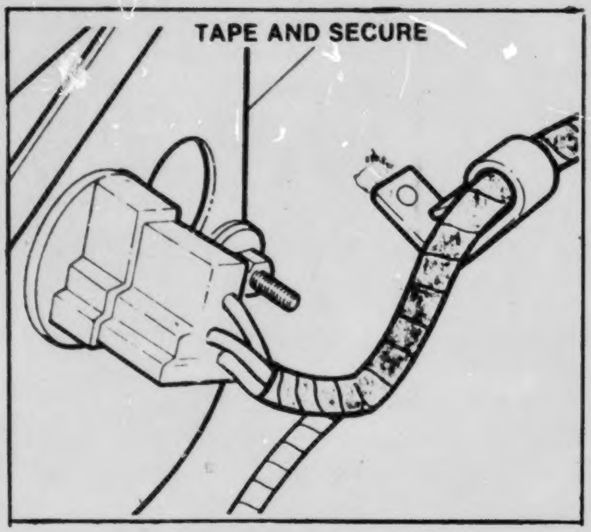
CONCLUSION. We have cut away the shorted part of the circuit. The short is somewhere in the area marked in gray.

Step 5. Verify the cause of the problem


RIGHT LAMP
WIRE 140

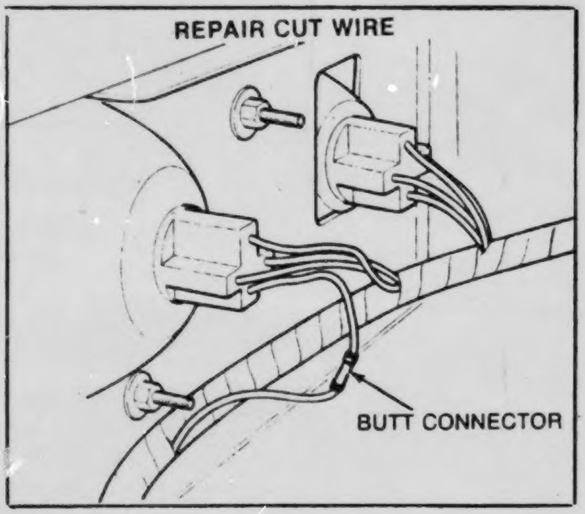
We next look over this section of wiring. Wire 140 could be shorted to the ground wire in the harness, but the actual problem is a very visible one. It is chafed against a rear lamp mounting screw. The insulation is broken and the screw is grounding circuit 140. Someone may have been careless in replacing a bulb or other repair in this area.

Step 6. Repair.



To repair the wire, tape it up with insulating tape. Also tape the excess slack to the rest of the harness to keep it away from the screw.

Make it a rule that whenever you work on electrical wiring you secure the wire and/or harness when you're done to avoid contact with noninsulated surfaces, especially moving parts.



Also install a crimp-on butt connector to reconnect the wire where it was snipped.

Step 7. Test the repair

Make a final check, then, that the circuit is okay. Install a new fuse, and operate the backup lights. Check visually that they go on and stay on.

Summary . . . How we diagnosed this short to ground

In this diagnosis, we had several circuits fed from the same fuse. We first determined which of these circuits made the fuse blow by turning them on one at a time. (If the short had been ahead of the switch, we could have disconnected them all and hooked them up one at a time.)

We isolated the circuit by removing the fuse and the ground for the bulbs. (If the bulb sockets were directly grounded, we could have removed the bulbs.) Then, we connected a self-powered test light from ground to the circuit fuse terminal making sure the common circuits were "off." The test light comes "on" at the fuse terminal which gave us a short to ground indication with the backup lamp switch closed. We opened connectors one at a time to further isolate the problem. (When we got rid of the short, the test light stayed off). Visual inspection of the isolated section of wire completed the diagnosis and verification of the defect.

Home Made "loud" Test Light

A more convenient short circuit tester is what we call a "loud test light". You can make this yourself with a sealed beam, a flasher or 7-amp circuit breaker, and some wire.

1. Connect one test lead to the ground terminal of the sealed beam. (If you can get ahold of a sealed-beam connector, it will make repair of the tester simpler if the sealed beam burns out).

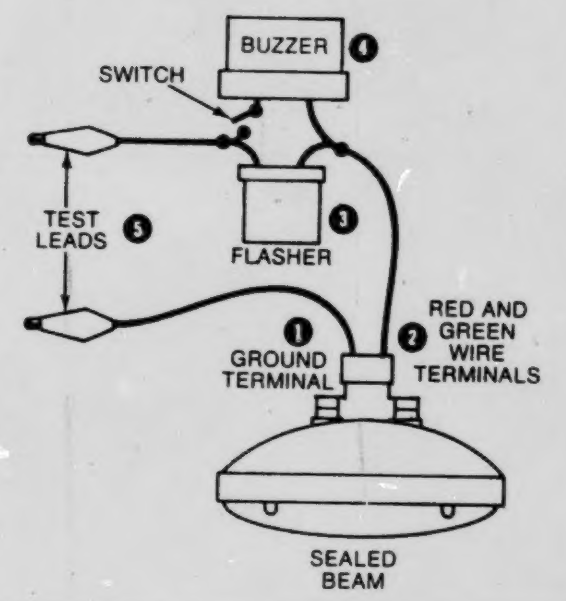
2. Wire the high beam and low beam terminals together and attach a second test lead.

3. Connect the flasher or breaker in series with the sealed beam.

4. It is also desirable, but not necessary to connect a buzzer in parallel with the flasher. Also, an on-off switch in one of the buzzer leads will make its signal optional during testing.

5. Make yourself various adapters from old wiring harnesses so you can connect the tester leads into circuits at the fuse panel, connectors, etc. It's also desirable to mount the tester components in a box (see next page) for convenience and to prevent damage.

HOW TO MAKE A "LOUD" TEST LIGHT



How To Use the "Loud" Test Light

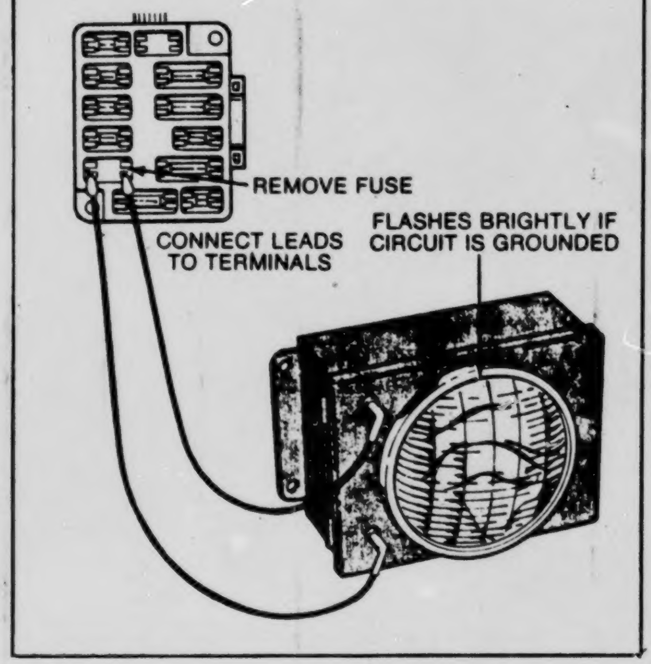
To use this tester, you connect it in series with the circuit you're testing, and use battery power to "feed" it. When the circuit is closed and full power is supplied, the sealed beam will flash on and off brightly. Also it will buzz intermittently if you have the buzzer connected and turned on.

There are two big advantages to using this device:

1. You can hook it up and leave your hands free to work. Even at the other end of the car from where you're working, it will "tell" you plainly what's going on in the circuit.
2. You don't have to isolate the circuit from ground. If the test lamp grounds through the load, it will flash very weakly and just barely buzz. If it grounds through a dead short, it will signal loud and clear. There's no mistaking the difference.

We will use this tester in demonstrating the diagnosis of the next two problems. Remember, though, that the self-powered test light could be used also. Of a 12-volt test light could be used, provided it's connected in series with the battery and the circuit.

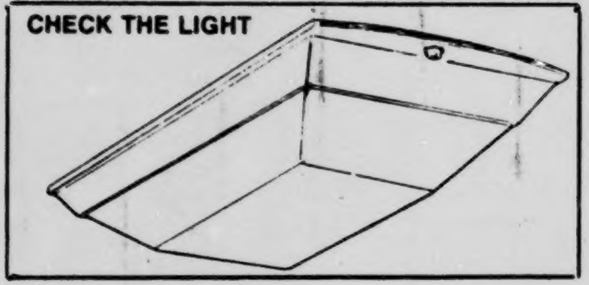
TYPICAL CONNECTION OF "LOUD" TESTER


REMOVE FUSE
FLASHES BRIGHTLY IF CIRCUIT IS GROUNDED
CONNECT LEADS TO TERMINALS

Problem #2- Dome Light Doesn't Work

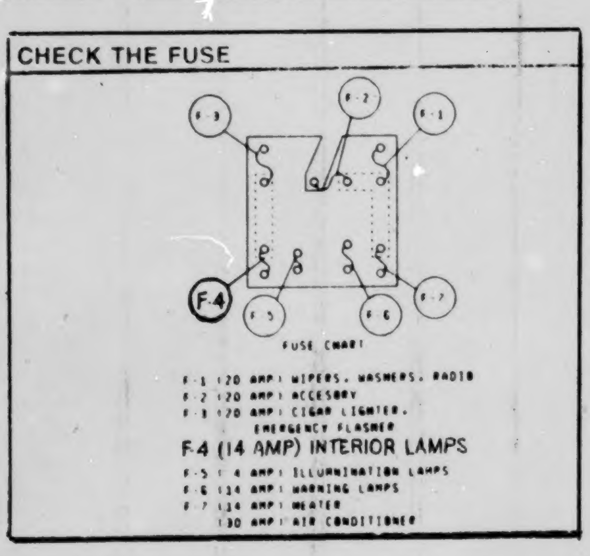
This problem occurred on a Maverick, but the circuits involved are just about the same on all car lines. The R.O. read: "Dome light doesn't work, third complaint. Fuse was replaced on (two earlier dates)." This note helps us to go beyond replacing the fuse, to also locate the cause of the fuse blowing.

Step 1. Verify the Complaint


CHECK THE LIGHT

To determine the problem, open the driver's door. The door jamb switch closes, but the dome light doesn't come on.

Step 2. Define the Type Of Problem

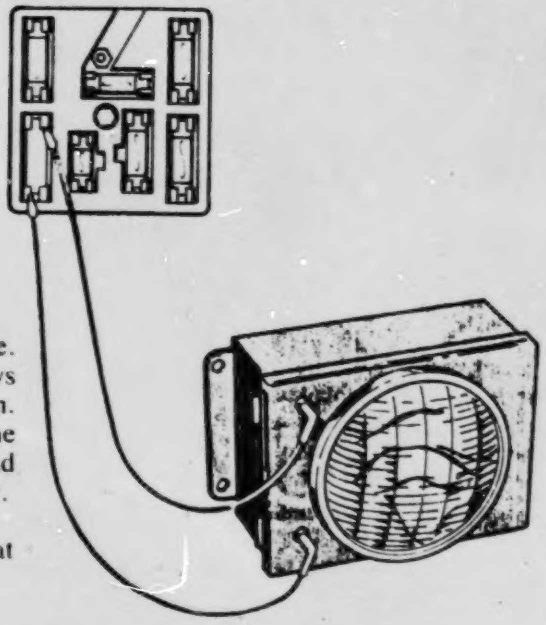

CHECK THE FUSE
F-3
F-2
F-1
F-4
F-5
F-6
F-7
FUSE CHART
F-1 (20 AMP) WIPERS, WASHERS, RADIO
F-2 (20 AMP) ACCESORY
F-3 (20 AMP) CIGAR LIGHTER,
EMERGENCY FLASHER
F-4 (14 AMP) INTERIOR LAMPS
F-5 (4 AMP) ILLUMINATION LAMPS
F-6 (14 AMP) WARNING LAMPS
F-7 (14 AMP) HEATER
(30 AMP) AIR CONDITIONER

Next, check the fuse. The wiring diagram identifies fuse number four for the interior lamps. Pull it out and observe that it is blown.

At this point, you are pretty sure that you have a short in a circuit. The next logical step would be to install a new fuse and find out when the fuse blows. But wait...
We have just built an excellent fuse substitute for short circuit testing. So...

Connect the Loud Test Light

CONNECT THE LOUD TEST LIGHT



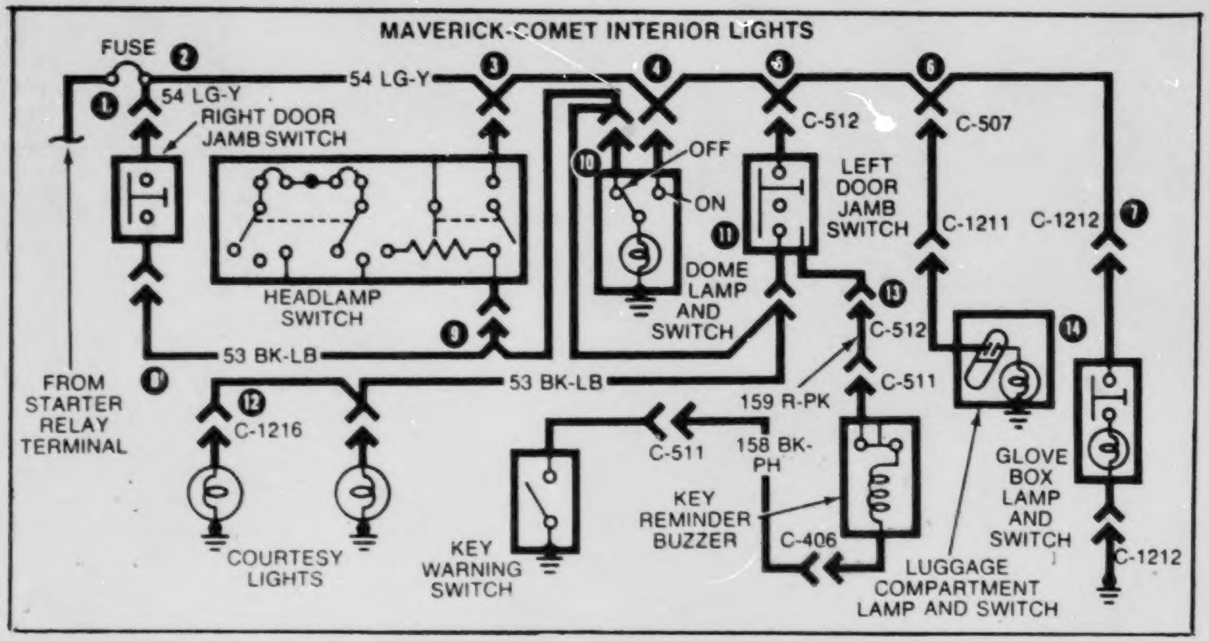
So we'll connect the loud test light in place of the fuse. With the test light installed, we observe that it glows faintly and buzzes softly with the driver's door open. This tells us that the circuit is grounding through the dome light and courtesy lights. But there's no dead short in the circuit yet, or it would be glowing brightly.

So it's time to consult the wiring diagram and see what else is on this fuse.

Step 3. Isolate the Problem

Trace the Circuit-
To trace this circuit, we first went to the power distribution page of the diagram and located fuse #4.
1. The fuse is battery hot, fed from the starter relay main feed terminal. It protects all the circuits powered by wire 54 LG-Y (light green with yellow tracer).
2. Wire 54 is marked in gray on our schematic. There are two branches from the fuse terminal. One branch is connected to the right-hand door jamb switch (if the car is so equipped).

The other branch of wire 54 goes to:
3. The power-in terminal of the rotary courtesy lamp switch in the headlamp switch assembly...
4. The power-in terminal of the overhead dome lamp switch, if the car is so equipped...
5. The power-in terminal of the driver-side door jamb switch...
6. A connector that continues circuit 54 to the rear to power the luggage compartment lamp...
7. And finally to the glove box lamp and switch assembly.



MAVERICK-COMET INTERIOR LIGHTS

FUSE
①
②
54 LG-Y
54 LG-Y
③
④
⑤
⑥
RIGHT DOOR JAMB SWITCH
C-512
C-507
OFF
⑩
ON
LEFT DOOR JAMB SWITCH
C-1211
C-1212
⑦
⑪
HEADLAMP SWITCH
DOME LAMP AND SWITCH
⑬
C-512
⑭
⑨
53 BK-LB
⑧
FROM STARTER RELAY TERMINAL
53 BK-LB
⑫
C-1216
C-511
159 R-PK
C-511
158 BK-PH
GLOVE BOX LAMP AND SWITCH
KEY REMINDER BUZZER
C-406
C-1212
COURTESY LIGHTS
KEY WARNING SWITCH
LUGGAGE COMPARTMENT LAMP AND SWITCH

Now let's follow wire 53 black, which powers the courtesy and dome lamps when one or more of the switches are closed:

8. From the power-out terminal of the right door-jamb switch...
9. To the power-out terminal of the rotary switch...
10. To the dome lamp...
11. To one power-out terminal of the driver's door jamb switch...
12. And to the right and left hand courtesy lamps.

With this arrangement, the dome lamp and the courtesy lamps are on whenever any one of the switches is closed.

13. Notice that the left door jamb switch has an extra power-out terminal. This powers the key reminder buzzer circuit. The buzzer will sound when the door jamb switch closes and the key warning switch closes to ground the circuit.
14. The luggage compartment lamp and glove box lamp systems are independent of the courtesy light controls. They just happen to be powered by the same fuse. Of course, either one of them could be the culprit in this problem.

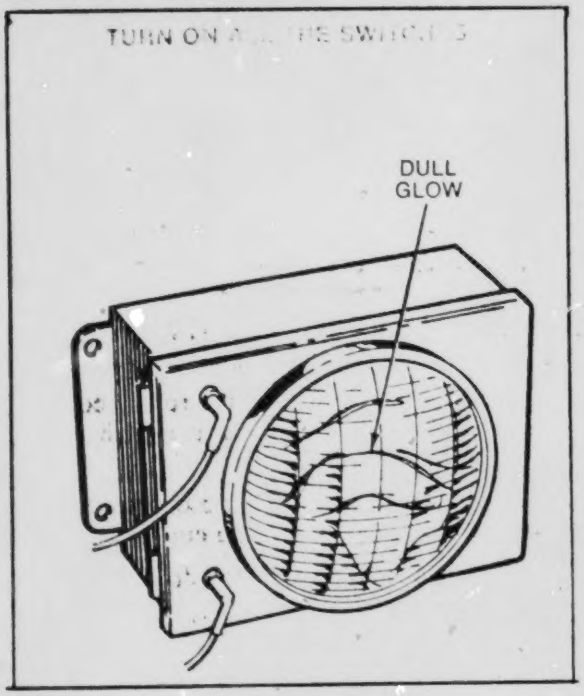
Look for common points.

As in our last example the first common point in a short circuit test is the common power source for all circuits served by the protection device. In this case, however, we must also consider a multi-parallel-switch circuit. Each of the switches in the dome light circuit can operate that circuit. One of the switches not only operates the dome light circuit, but also allows energization of a branch circuit for the key warning buzzer.

The circuits or sub-circuits in common include:

1. Glove box lamp
2. Luggage compartment lamp
3. Left door jamb switch for key buzzer
4. Left door jamb switch for done lamp and courtesy
5. Dome lamp and courtesy
6. Headlamp switch for dome and courtesy lamp
7. Right door jamb switch for dome lamp and courtesy

Try common components.

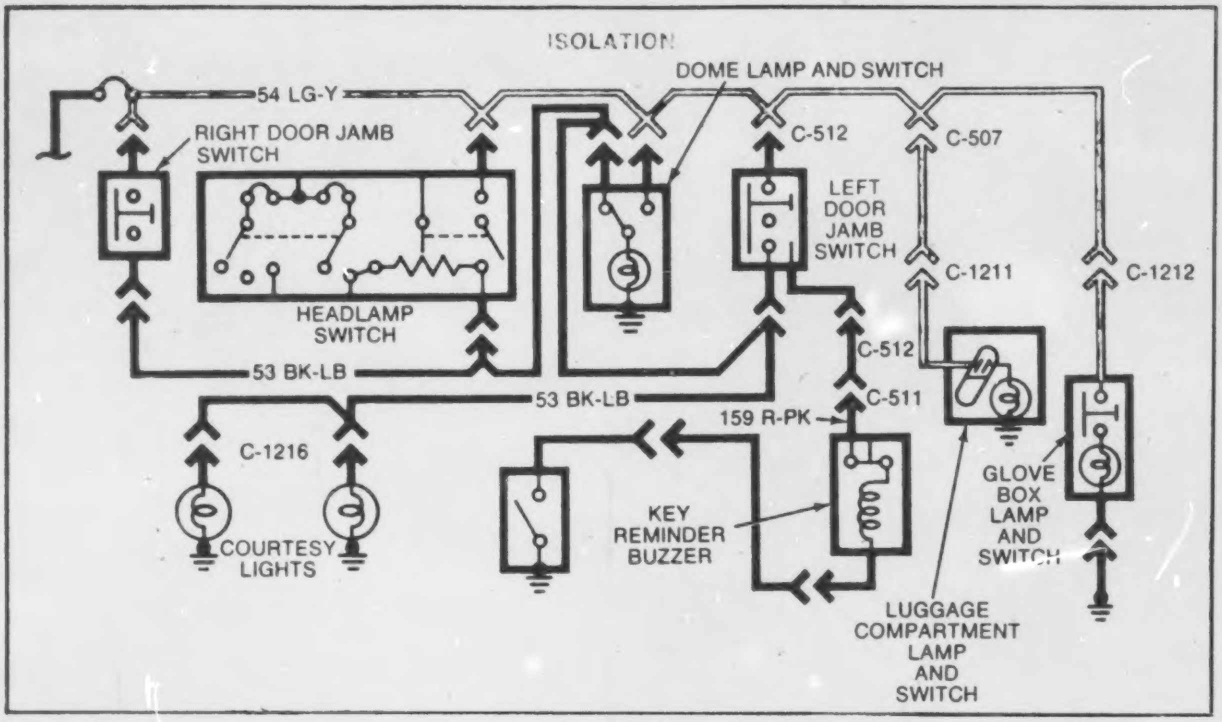


To proceed with isolating the problem, we turn on all the switches, one at a time, and watch the tester. Start by opening the driver door and inserting the ignition key to activate the buzzer circuit. Also open the right door, the glove box and the trunk. Turn the headlamp switch knob to on, and the overhead dome lamp switch to on.

In each case, all we got on the tester at this point was a dull glow; no indication of a dead short. But since the fuse has blown twice before, we suspect an intermittent short. There must be a bare wire somewhere that touches ground when the car goes over a bump or vibrates.

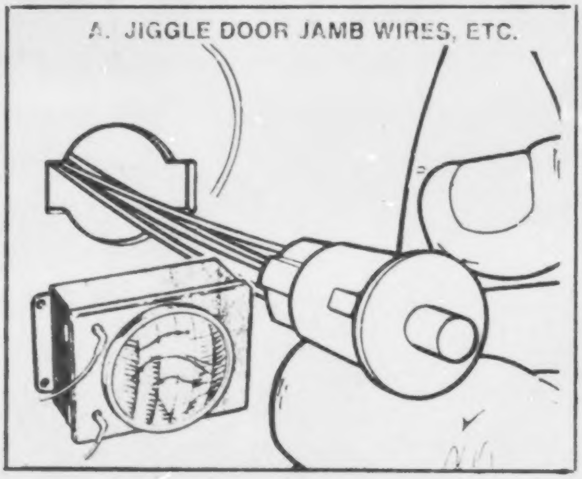
Use Logic

Since the car must be driven to induce the short, we can now logically eliminate half of the circuit from consideration. During road operation, all switches in this circuit are open (off). We can now isolate the problem to "circuit 54"- the direct power feed to all circuits ahead of the switches - which is live at all times. (See light colored circuit in the following illustration.


ISOLATION
DOME LAMP AND SWITCH
54 LG-Y
RIGHT DOOR JAMB SWITCH
C-512
C-507
LEFT DOOR JAMB SWITCH
HEADLAMP SWITCH
C-1211
C-1212
53 BK-LB
C-512
53 BK-LB
C-511
159 R-PK
C-1216
GLOVE BOX LAMP AND SWITCH
KEY REMINDER BUZZER
COURTESY LIGHTS
LUGGAGE COMPARTMENT LAMP AND SWITCH

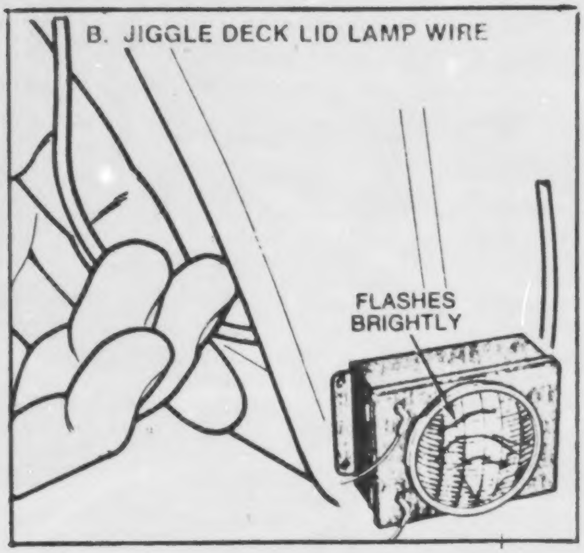
Although "Circuit 54" is a rather long segment, this is the smallest segment which can be isolated using the common point diagnosis method. Further isolation must be done by testing.

Step 4. Test Systematically
Our test procedure then is to go around the car and jiggle wires to try and make the short happen. If the bare wire touches ground, the loud test lamp will get very loud and very bright. In this, we'll observe Zimmerman's first law: start with the easiest to get at places.


A. JIGGLE DOOR JAMB WIRES, ETC.

TEST A. Pry out the door jamb switches and jiggle the light green wire.

RESULTS. Only a dull glow in the tester.

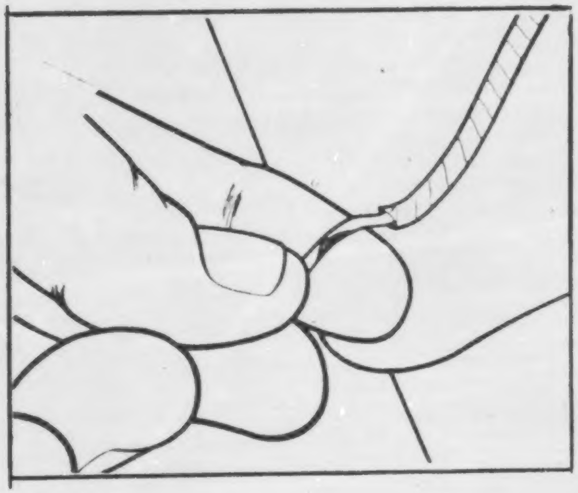

B. JIGGLE DECK LID LAMP WIRE
FLASHES BRIGHTLY

TEST B. Open the trunk and jiggle the wire that leads to the trunk lamp.

RESULTS. The tester signals a short by flashing brightly.

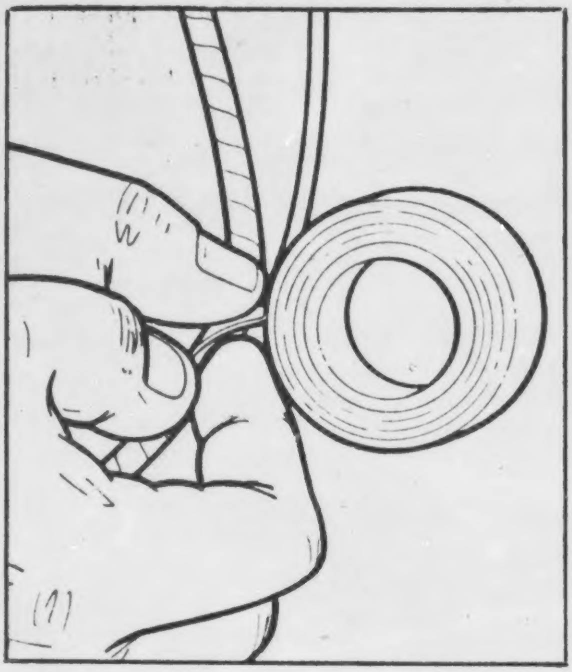
CONCLUSION. A bare spot on the wire is grounding.

Step 5. Verify the Cause of the Problem



We then inspect the wire visually. A clip that secures it is not attached. The wire has chafed against a sharp edge on the deck lid hinge, and removed some of the insulation. When it touches bare metal, the fuse blows.

Step 6. Repair



We repair the wire by taping it up with insulating tape. Also, to prevent a recurrence of the problem, slip a split length of vacuum hose over the section of the wire that's near the hinge. And clip the wire up away from the hinge.

Step 7. Test the Repair

To finish the job, remove the loud tester and install a new fuse. Check that all the components on circuit 54 operate okay.

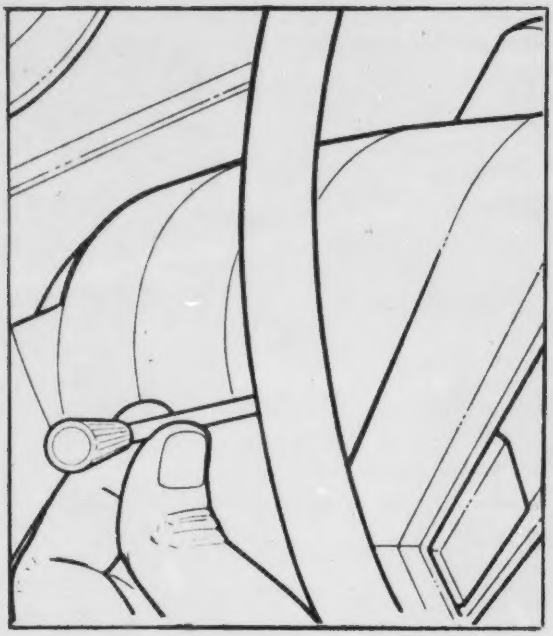
SUMMARY- DIAGNOSIS OF INTERMITTENT SHORT TO GROUND

To diagnose an intermittent short to ground, we first checked to find out what circuits were connected to the fuse that burned out. We then connected the tester in place of the fuse and tried to make the short happen. It didn't happen when we closed the switches one at a time, so we had to jiggle wires. Had we not discovered the short this way, our last resort would be to trace all the wires on the car and check visually for the short. Occasionally that will be required, but systematic testing first should always be the rule.

Problem #3- Horn Blows With Turn Signal

This problem is a short between two circuits, or a cross-circuit short. The repair order says: "Horn blows when the turn signal is operated."

Step 1. Verify the Complaint



To determine the problem, we turn on the ignition to power the turn signals, and flip the turn signal switch to the right turn position. The right turn signals operate okay.

So we move the lever to left turn. Now the horn beeps each time the flasher closes the circuit. The horm circuit is crossed with the left turn circuit.

To double check, push the horn button. The horn blows and the left turn indicator light comes on.

Step 2. Define the Type of Problem

With the obvious symptoms above, we most certainly have a short between two circuits. Both circuits work together when any one circuit is activated.

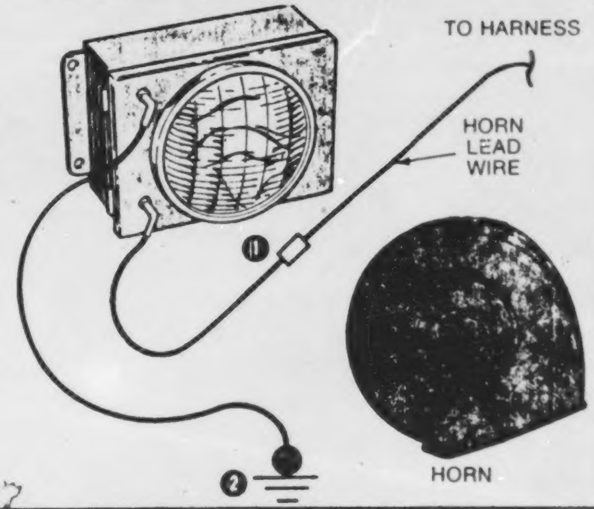
Hook up the test light... and try to make the problem (short) go away.

In diagnosing this problem, we're going to trace the circuits and open connectors to try and make the problem go away. Since the horn makes too much noise, we'll substitute the loud test light as follows:

① Remove the hot wire at the horn and connect it to one lead of the tester.

② Connect the other tester lead to ground.

Now, when we press the horn switch or turn on the left turn signal, the tester flashes brightly.

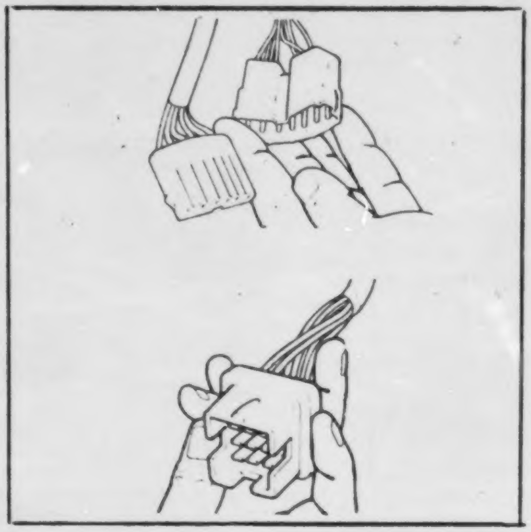


Step 3. Isolate the Problem

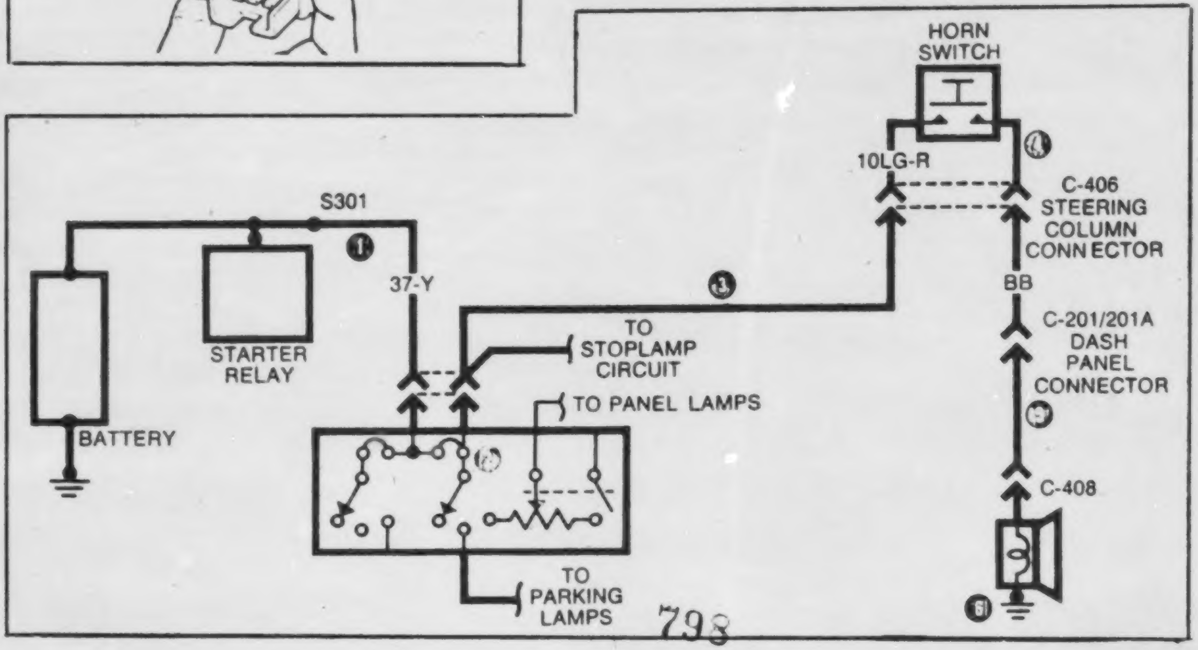
The use of a wiring diagram will aid our problem isolation by providing information on common circuit runs. The two circuits must be viewed individually, taking note of multi-terminal connectors and their location. The common circuit runs will be located near the commonly shared multi-connectors.

The Horn Circuit

The horn circuit is very simple (see below).
1. Power is from the starter relay main feed terminal via wire 37 yellow to the main power-in terminal of the headlamp switch.
2. From there, the parking and instrument lamp circuit breaker also protects the horn and stoplamp circuits on this model car.
3. Wire 10, light green with red tracer, continues the circuit through the crescent-shaped steering column connector C-406 to the horn switch.



4. Power out of the horn switch is via wire 1, basic blue. The circuit goes back to the steering column connector, then to the dash panel connector C-201 and 201A. This connector joins the under hood wiring harness to the interior wiring and fuse block.
5. Wire 1 blue continues through the unerhood harness to connector C-408 at the horn. (This is where we connected the loud test light.)
6. The horn is self-grounded to the chassis to complete the circuit.

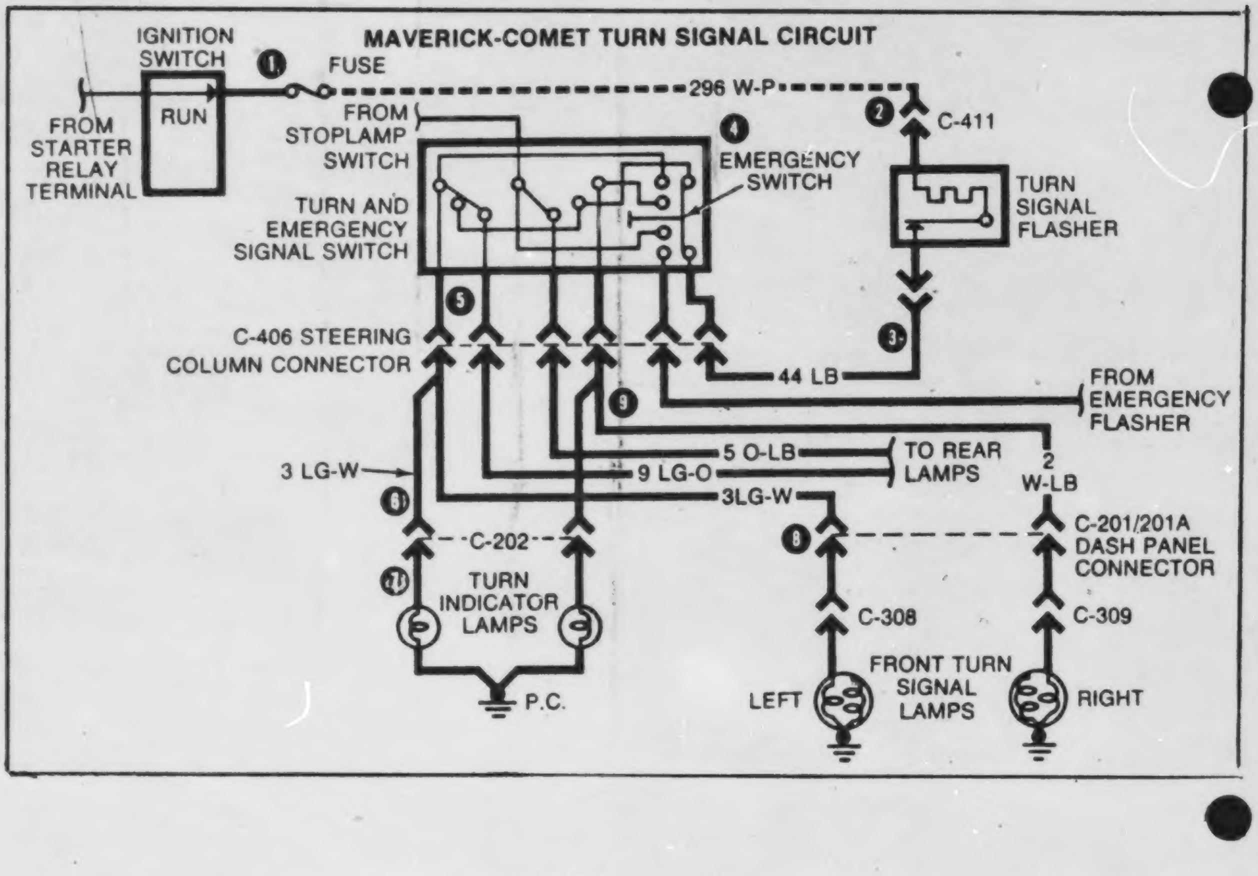

HORN SWITCH
10LG-R
④
C-406 STEERING COLUMN CONNECTOR
S301
❶
37-Y
❸
BB
C-201/201A DASH PANEL CONNECTOR
STARTER RELAY
TO STOPLAMP CIRCUIT
TO PANEL LAMPS
②
⑤
BATTERY
C-408
TO PARKING LAMPS
❻

The Turn Signal Circuit

The turn signals are operated by a flasher and by the turn and emergency signal switch. The switch also operates the emergency flasher lights, which use the same lamps as the turn signals. When the switch is on emergency flasher, the turn signals do not operate.

The rear stoplamps also are the same bulbs as the turn and emergency signals, and are fed through this switch.

Let's trace the turn signals:
1. Power is from the ignition switch in the RUN position. A fuse protects the circuit from overload.
2. Wire 296, white with purple tracer, continues the circuit to the turn signal flasher. The flasher opens and closes as its bi-metal alternately cools and heats when the circuit is operating.
3. Wire 44 light blue continues the circuit to the switch, through the steering column connector C-406.

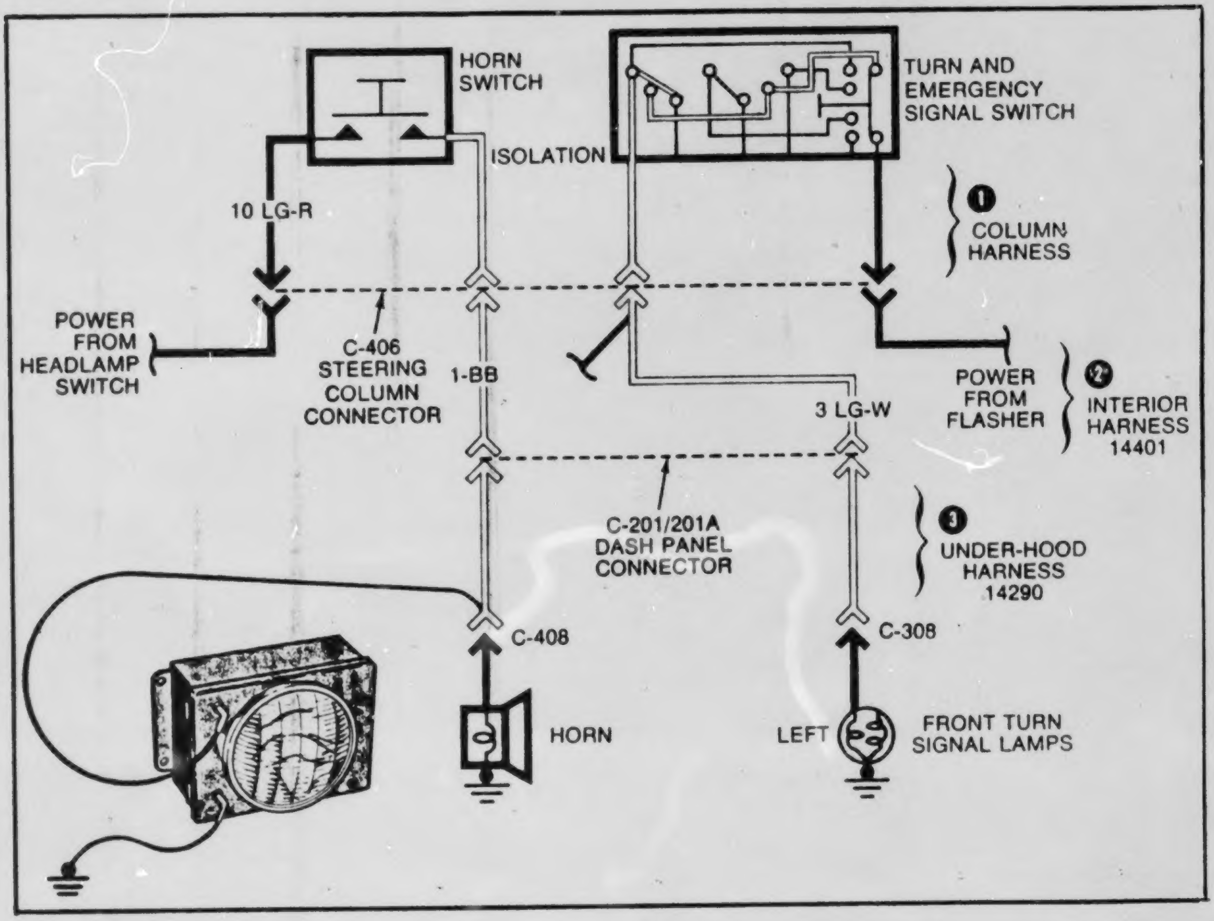

MAVERICK-COMET TURN SIGNAL CIRCUIT
IGNITION SWITCH
RUN
FROM STARTER RELAY TERMINAL
①
FUSE
296 W-P
②
C-411
FROM STOPLAMP SWITCH
④
EMERGENCY SWITCH
TURN AND EMERGENCY SIGNAL SWITCH
TURN SIGNAL FLASHER
⑤
C-406 STEERING COLUMN CONNECTOR
③
44 LB
FROM EMERGENCY FLASHER
⑨
5 O-LB
9 LG-O
TO REAR LAMPS
2 W-LB
3 LG-W
3LG-W
⑥
C-202
⑧
C-201/201A DASH PANEL CONNECTOR
⑪
TURN INDICATOR LAMPS
C-308
C-309
P.C.
LEFT
FRONT TURN SIGNAL LAMPS
RIGHT

4. The emergency switch is in the OFF position, so that it closes the turn signal feed contacts in the switch.
5. For a left turn, wire 9 carries power to the rear lamp. It goes through the steering column connector and then to a connector at the left cowl side before continuing to the rear.
6. At the same time, wire 3, light green with orange tracer, feeds the left front turn signal lamp and the left turn indicator lamp. It is split at the male terminal of the steering column connector.
7. The left turn indicator lead goes to connector C-202, which is the printed circuit connector
8. Wire 3 goes to the dash panel connector, then via the under-hood harness to connector C-308 at the left turn signal lamp.
9. For a right turn, wire 2 powers the front lamp and indicator lamp, and wire 5 the rear lamp. The wire routing is the same.

Common Circuit runs

From the two separate diagrams, we can develop a list of common connectors. These include C-406, the steering column connectors, and C201/201Z, the dash panel connector.

Using logic we began to isolate this problem when we determined it.


HORN SWITCH
ISOLATION
TURN AND EMERGENCY SIGNAL SWITCH
10 LG-R
❶
COLUMN HARNESS
POWER FROM HEADLAMP SWITCH
C-406 STEERING COLUMN CONNECTOR
1-BB
POWER FROM FLASHER
❷
INTERIOR HARNESS 14401
3 LG-W
C-201/201A DASH PANEL CONNECTOR
❸
UNDER-HOOD HARNESS 14290
C-408
C-308
HORN
LEFT
FRONT TURN SIGNAL LAMPS

First, it happened only when we closed one switch or the other. So the problem must be beyond the switches. This fact eliminates all the power feed to switch wiring in the two diagrams.

Second, it happened only in a left turn. So we're sure it's wire 3 or 9 that's crossed with wire 1. We can forget about the right turn wires.

To further isolate it, we push in the horn switch and look at the left rear turn signal lamp. The lamp doesn't come on. Thus, we have eliminated wire 9.

Step 4. Test Systematically

The first step to systematic testing is to break the circuit down into simpler parts.

We will test, then, in the parts of the circuit, beyond the switches, where wire 3 and wire 1 run together. As the diagram shows, there are three harness sections involved:

1. The steering column harness up to connector C-406.

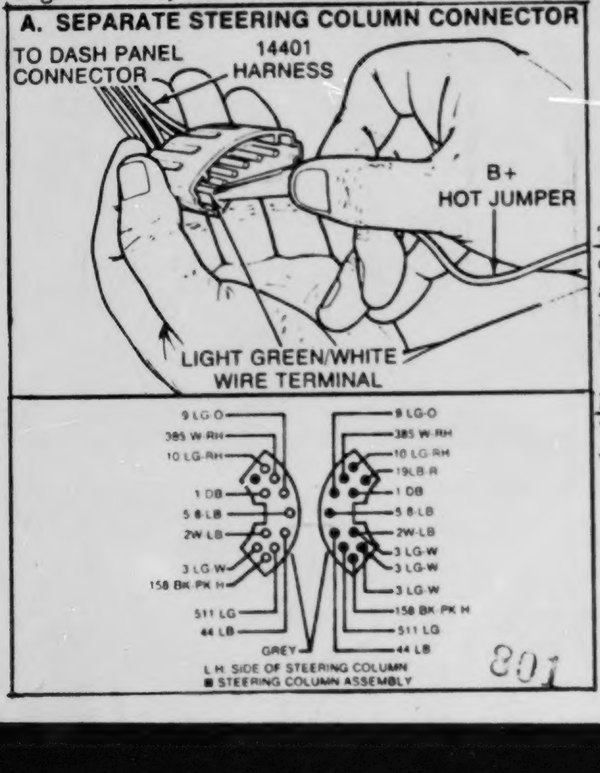
2. The interior harness between C-406 and C-201.

3. The under-hood harness between C-201 and where the blue wire leaves the harness to go to the horn.

The cross-up has to be in one of these harness segments, or in one of the two connectors C-406 or C-201.

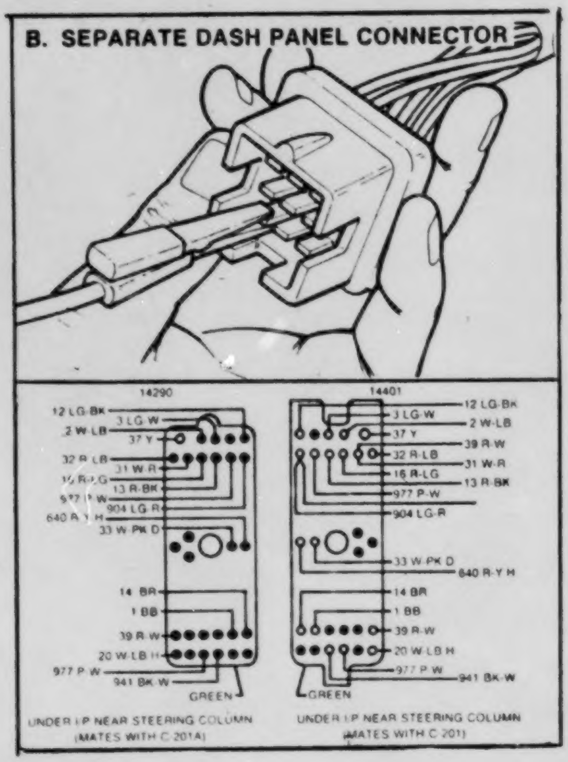
Our test procedure this time is to first isolate the short by opening connectors. The tester is plugged in place of the horn, so if we apply power to the turn signal wire, the tester will tell us if the short is still in the circuit.

A. SEPARATE STEERING COLUMN CONNECTOR


TO DASH PANEL CONNECTOR
14401 HARNESS
B+ HOT JUMPER
LIGHT GREEN/WHITE WIRE TERMINAL
9 LG-O
385 W-RH
10 LG-RH
1 DB
5 8-LB
2W LB
3 LG W
158 BK-PK H
511 LG
44 LB
GREY
9 LG-O
385 W-RH
10 LG-RH
19LB-R
1 DB
5 8-LB
2W-LB
3 LG-W
3 LG-W
3 LG-W
158 BK-PK H
511 LG
44 LB
L.H. SIDE OF STEERING COLUMN
■ STEERING COLUMN ASSEMBLY
801

Test A. Separate the steering column connector, connect a jumper wire from any hot terminal on the car (starter relay or fuse block) to the male terminal of wire 3 on the connector.

RESULTS. The tester flashes brightly. The turn signal wire is still crossed with the horn wire.

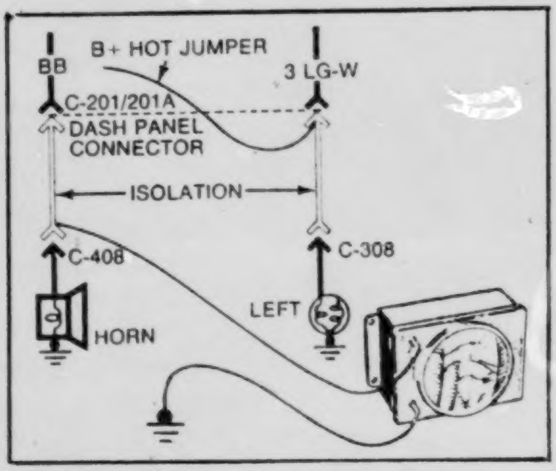

B. SEPARATE DASH PANEL CONNECTOR
14290
12 LG-BK
3 LG-W
2 W-LB
37 Y
32 R-LB
31 W-R
16 R-LG
13 R-BK
977 P-W
904 LG-R
640 R-Y H
33 W-PK D
14 BR
1 BB
39 R-W
20 W-LB H
977 P-W
941 BK-W
GREEN
UNDER I.P NEAR STEERING COLUMN (MATES WITH C-201A)
14401
12 LG-BK
3 LG-W
2 W-LB
37 Y
39 R-W
32 R-LB
31 W-R
16 R-LG
13 R-BK
977 P-W
904 LG-R
33 W-PK D
640 R-Y H
14 BR
1 BB
39 R-W
20 W-LB H
977 P-W
941 BK-W
GREEN
UNDER I.P NEAR STEERING COLUMN (MATES WITH C-201)

Test B. Separate the dash panel connector, under the hood, apply power to the terminal for wire 3, going into the under-hood harness.

RESULTS. The tester flashes brightly.

CONCLUSION. The crossed wires are in the under-hood harness.

By applying power as shown in the diagram, we've determined that the wires are crossed in the under-hood harness. We'll conclude our testing by leaving the jumper and test light in place, and see if we can make the short go away.

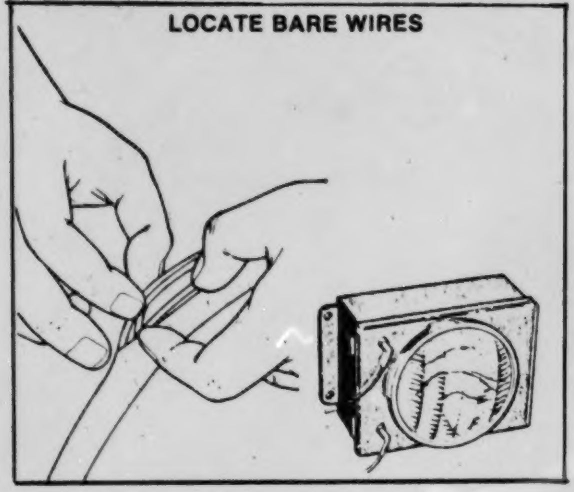

BB
B+ HOT JUMPER
3 LG-W
C-201/201A
DASH PANEL
CONNECTOR
ISOLATION
C-408
C-308
HORN
LEFT

Test C. Jiggle, twist and pull on the harness along its length, while watching the test light.

RESULT. The light goes off as we twist the harness near the hood hinge. We've found the short.

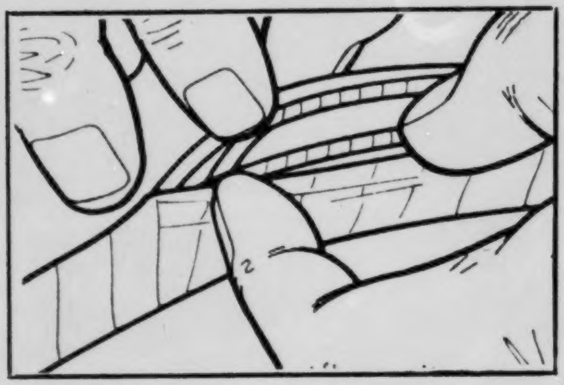
Step 5. Verify the cause of the problem

So we now pull the harness up and unwrap it, and look for the bared wires. Locate them and touch the bare spots, and the tester flashes. Separate them, and it stops flashing.



Looking closely at the harness, we discovered that it had been repaired previously, apparently after getting pinched by the hinge. But the wires weren't inspected carefully enough, and the harness was taped up with these two wires bare.

Step 6. Repair



We'll tape up the damaged wires, and check if any others are damaged. Then we'll tape the harness and secure it properly with clips.

Step 7. Test the repair

Finally, we test the operation of both the horn and turn signals. They work okay and no funny effects. Diagnosis and repair completed.

Problem #4 Battery Drain - High Resistance Short to Ground

This problem has no specific example since the actual systematic testing and repair methods follow those of a normal short. For this problem, we will cover complaint verification, defining the type of problem, and problem isolation. The test methods involve the use of a ammeter (see competency A-3, How to Use An Ammeter.)

Complaint - Battery goes dead after the car sits for three days

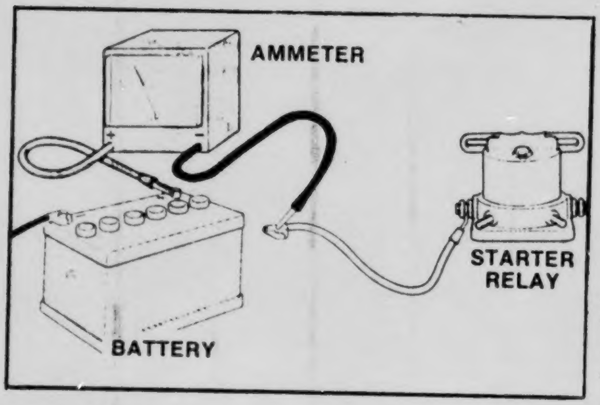
Step 1. Verify the Complaint

Since this isn't an observable problem, complaint verification cannot be done by trying a circuit or looking at a component. Here we'll have to do some testing to verify the problem.

Step 2. Define the type of problem

Based on our complaint, we would first assume a battery problem. Battery testing is the subject of Competency B-(1-9). In this case, the battery is OK. The next step is to perform a battery drain test.

Sometimes a high resistance short to ground can drain the battery without blowing a fuse. This type of short can be difficult to locate. To verify that there is a high-resistance short to ground. Perform the test below.



Test A

1. Turn off all electrical systems.
2. Disconnect the battery positive cable.
3. Connect a 3-4 amp scale ammeter between the battery positive post and the removed cable or the cable stud on the starter relay. (Be sure to observe polarity as with the voltmeter.)
4. Read the current draw on the ammeter.

RESULTS. Ammeter reads 1.1 amps.

CONCLUSION. (See note below)

There should be no current draw when all electrical systems are shut off. Any current draw indicates a short somewhere in the system.

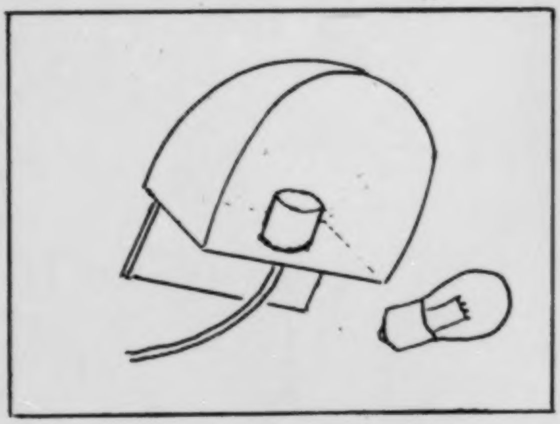
Note: Systems with electric clocks may draw some current for a short period of time. Allow a few seconds for the clock to wind before taking a current draw reading. Digital clocks draw current constantly and should be disconnected while making this test.

How Much Current Draw is Allowed?

Late-model cars equipped with diodes and transistors in generators, pulse wiper systems, anti-theft alarm systems, illuminated entry systems, and seat belt warning systems will have a constant current draw due to leakage across these electronic components. Such leakage is an accumulation in milliamperes and not considered significant. Keep in mind that a discharge of one ampere would require 63 hours to discharge a 63 ampere-hour rated battery. A discharge of 0.1 ampere would require 630 hours or 27 days to completely discharge. A reading of less than 0.5 ampere is considered negligible.

Step 3. Isolate the Problem

To begin our isolation, we can make some easy checks of some highly suspect areas. For example, walk around the car to make sure that all the exterior lights are out; a switch stuck in the closed position could keep the brake lights on. Examine the interior lighting with attention to concealed lights in the glove box, luggage compartment and under the hood.



Test B. Remove the lamps one at a time from the glove box, luggage compartment, and under the hodd. Observe the ammeter reading each time.

RESULTS. Ammeter reads up scale when the area is opened and returns to 1.1 amps when the bulb is removed

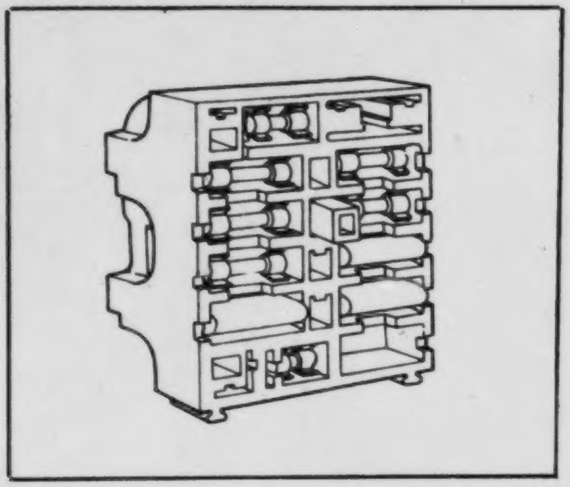
CONCLUSION. Our problem is not in any of these highly suspect areas.

Use Logic

Since the problem occurs when the car is parked with the ignition switch and headlight switch "off," we can, at this time, assume that the problem only involves those circuits receiving direct power from the battery.

The first common point for these circuits, is the main circuit junction typically located at the starter relay or at a junction block near the battery. A major second common point which derives its power from the main junction is the battery power side of the fuse panel.

Either of these common points will supply a large number of circuits. The most accessible, however, is the fuse panel. This is where we will make our next test.



Test C. To find the fused circuit with the undesired short, proceed as follows:
1. Leave the ammeter connected as in Test A and B.
2. Pull fuses from the fuse block.
3. Observe the ammeter after each fuse is removed.

When the ammeter needle drops to zero, the circuit where the short exists has been isolated.

RESULT. The needle of the ammeter drops to near zero when the courtesy light fuse is removed.

CONCLUSION. Our high resistance short to ground is in the circuits served by the courtest light fuse.

We would now continue our isolation by tracing and identifying the common circuits served by this fuse. In our example the clock circuit is also on this fuse. Reinstalling the fuse and disconnecting the clock circuit only, we find that our ammeter has again dropped to zero.

This problem turned out to be in the clock which is a highly suspect component. The wind up magnetic coil in most all clocks is actuated by a set of points linked to the main spring mechanism. When the main spring runs down, the points close actuating the magnetic coil which attracts and moves a winding lug. As the points are subjected to arcing and heat, they often stick closed energizing the coil full time and causing a constant drain without blowing the fuse.

If we had failed to identify the problem circuit in test C we would continue to test D.

Test D
To find a short in an unfused circuit, proceed as follows:
1. Leave the ammeter positive cable connected to the battery positive post as shown in Figure 104.
2. Disconnect the feed wires from the starter relay terminals or junction block.
3. Move the negative ammeter lead from one feed wire terminal to another.
4. Observe the meter scale.

The ammeter will show current on the terminal of the circuit having the short.

If we had failed to identify the problem up to this point, we would not have to go back to our original assumption that the problem exists before the headlight or ignition switch.

A shorted switch will allow power to reach circuits normally thought to go "off" when the switch was off.

Do any of the accessories (normally off with the ignition switch) operate when the ignition switch is off?

This problem may be isolated by disconnecting the switches and observing the ammeter.

Common Problems

Being able to identify suspect components and circuits may make isolation easier. The following are some of the more common problem areas.

1. hidden lights in glove box, trunk, under hood, etc. turned on

2. electric clock contacts fused

3. cigar lighter pushed in but making only poor contact (won't heat enough to disengage)

4. relay or solenoid energized normally through a switch left on (the controlled circuit or mechanism may be defective or its operation not noticed)

5. relay or solenoid coil energized through a high resistance circuit (bad connection). Lack of adequate current flow does not allow activation.)

6. buzzer unit coil energized through fused contacts (no buzzing sound)

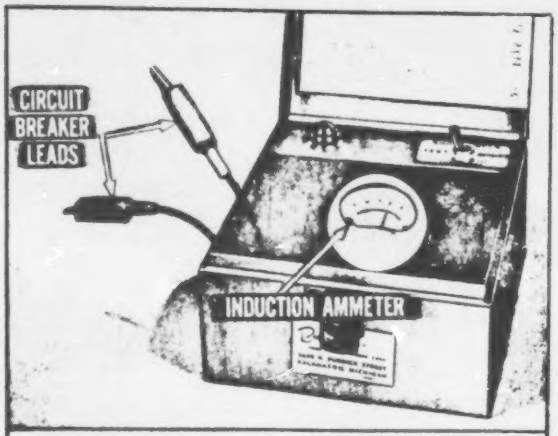
7. stuck switch activating a motor which has stalled. (For example, a stuck power window up function switch with window already fully up)

8. a partially burned out or defective motor with switch left on. (Motor will not operate but will draw some current.)

9. a partially activated sequenced warning circuit (some models). (For example, a seat belt not fully retracted which partially activates the warning system.)

Short Tester Checking Procedure

Locating a short circuit depends largely on the symptoms. As an aid in locating a "short" in a feed circuit, a labor-saving device known as a "short tester" (J-8681, BT-1120 or equivalent) may be utilized. Its advantage is the fact that it does not require trim removal prior to testing operations.



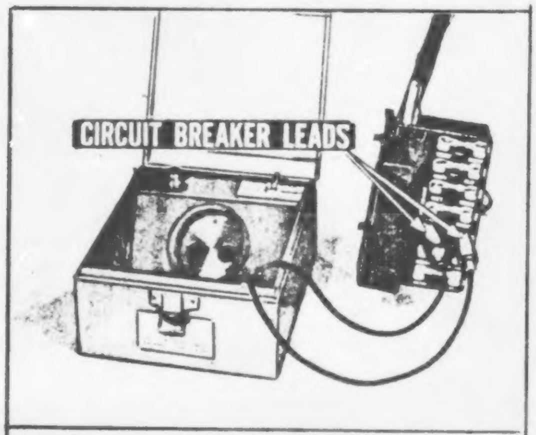
Short finder tool

All short testers have the following parts in common:

1. Two leads with alligator clips (for bypassing an existing circuit breaker or fuse).
2. A 10 to 15 amp circuit breaker (to replace the existing circuit breaker or fuse).
3. A meter for detecting intermittent electrical current.

The tester meter is designed to react to the magnetic lines of force that surround an energized wire or conductor. However, the current must be interrupted at intervals by means of a circuit breaker incorporated into the testing device in order to cause the meter needle to deflect. The use of a "short" tester should include the following steps:

1. Reference should be made to service manual electrical diagrams in order to establish proper wire color identification.



Connect circuit breaker

2. Disconnect the affected circuit breaker (both wires) or remove blown fuse and substitute either of these items with the circuit breaker of the tester. This is accomplished by connecting the tester leads to the input and output side of the fuse clip or wires previously removed from the existing circuit breaker.

3. The tester may respond immediately by making a snapping noise. (This sound may be accompanied by a warning light on some testers.) This response is an indication that the "short" is located in a FEED line between the power source and a switch. If the tester does not respond, proceed as follows:

a. Turn on or actuate all switches in the inoperative circuit.
b. Observe all lights or units affected by actuating all switches. The light or unit that DOES NOT operate intermittently but causes the tester to react is in the "shorted" circuit, and indicates the side of the car that is affected.

NOTE: When the affected circuit has been positively identified, reference should again be made to proper wire diagram as an aid in the steps that follow. In addition, switch in the circuit being checked must be held in closed position.

4. Beginning at power source for the inoperative circuit, place tester meter directly over the wire (or harness) with meter arrows parallel to the wire(s) being checked. The meter needle will deflect noticeably each time tester completes the circuit.

NOTE: Since this test will most often be made over intervening layers of trim material (cloth, rubber, plastic, metal), it may be necessary to move the meter laterally over the circuit at each check point to achieve the strongest signal on the meter.

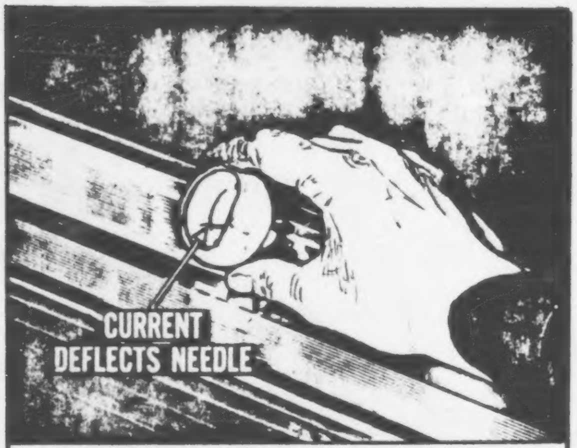


Fig. 24—Follow the harness

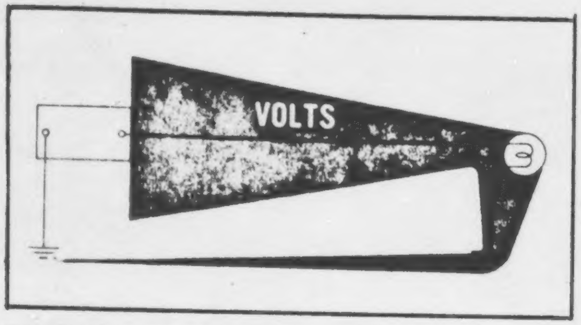
5. Check progressively with the meter along the circuit from the power source to the inoperative unit. A sharp DECREASE in the AMOUNT of meter needle deflection will indicate the location (within 4-5 inches) of the "short". It must be remembered, however, that the above meter reaction would also occur if the wrong circuit was followed or the meter was not held directly above the circuit (reference "NOTE", in step 4).

6. Once the location of the "short" is accurately established, necessary trim parts may be removed to perform repairs as outlined under Body Wiring Repair Procedures.

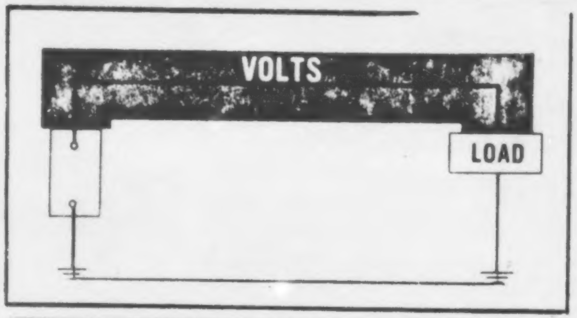
Using a Meter to Test Voltage Drop

Principles of voltage drop were covered in Competency A-2. The following material will provide a review and a test method.

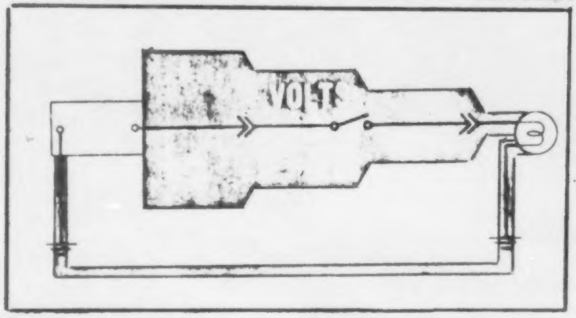
Voltage drop is best described as voltage lost.



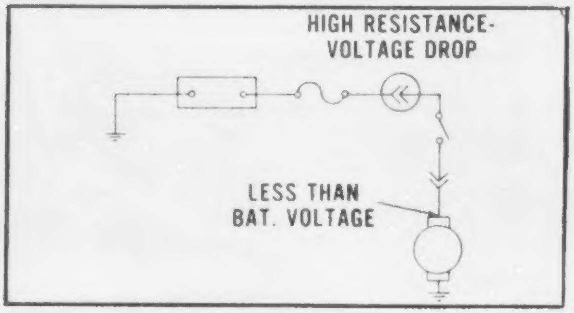
In any electrical circuit all of the applied voltage is used up by the time it goes from the positive post of the battery, all the way through the circuit, back to the negative post. That is, if we start with a battery voltage of 12.5 volts, we use it all up somewhere in the circuit.



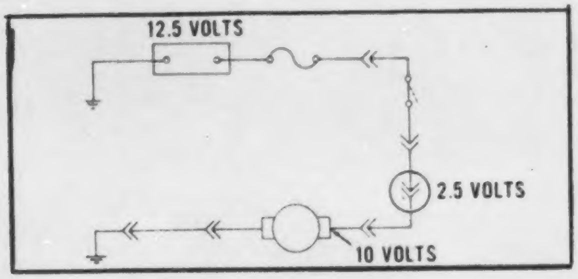
Ideally, we'd like to use up all of the voltage, or pressure, if you will, right at the load of the circuit. The load of a circuit is defined as that component or part that's supposed to operate. Typical loads are bulbs, motors, relays, etc. Unfortunately, we seldom reach the ideal; that is, we seldom design circuits and components so good that all of the voltage is used up at the load.



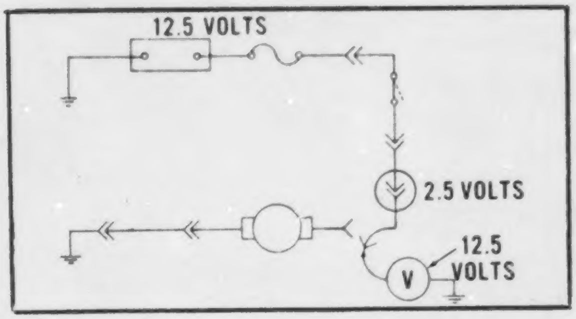
Instead, we find that in most electrical circuits we use up, or lose, some voltage before it actually gets to the load. Sometimes it's lost at connectors or through the contacts of a switch. In other cases, it's lost because of internal resistance in the wiring.



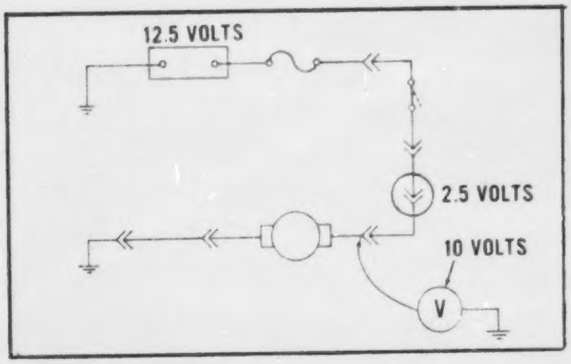
In all instances, voltage drop is the result of resistance; resistance that can sometimes cause some real problems. This resistance causes problems because it results in applying less than the normal amount of voltage to a working component. Now, this is especially critical in circuits which are designed to operate motors.



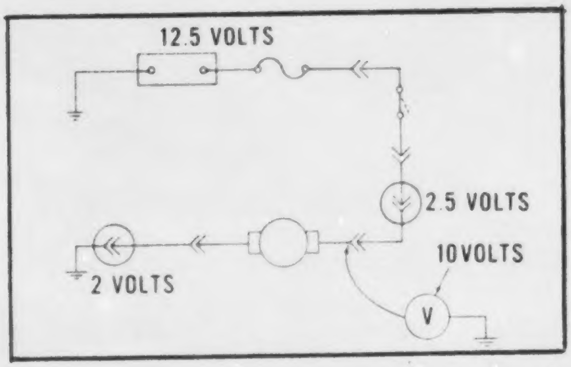
In the example shown, we've got a poor connection in the circuit to the motor. This poor connection, which is really a high resistance point, drops, or uses up, about 2.5 volts of battery pressure before it gets to the motor.
Now, if we started with a battery voltage of about 12.5 volts, only 10 volts would be applied to the motor. It's possible in this situation that the motor would lug and operate at a speed slower than normal.



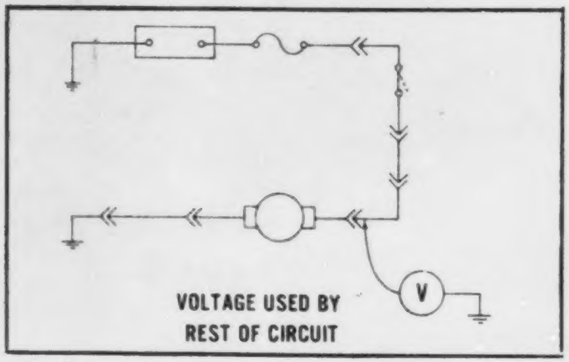
Now, here's where it gets a little tricky. Unless you're really careful, you may never notice the voltage drop. If you were to disconnect the motor connector and then connect a voltmeter between the power feed and ground, the voltmeter would indicate full battery voltage. That's right, the voltage drop would not show up, because of the method used to test the circuit. (For more information on this topic, see information sheet 5A.)



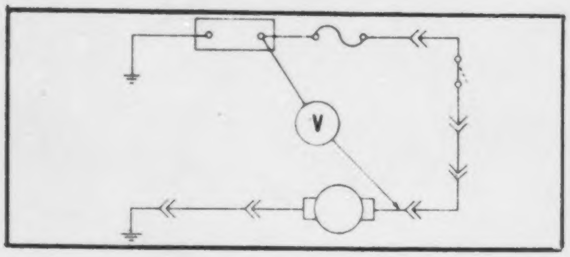
On the other hand, if you were to operate the circuit, leave the connector connected, and then stick the point of a voltmeter probe into the power feed wire, while connecting the other probe to ground, the meter would read about 10 volts. Now, don't jump to conclusions, even this test can be misleading.



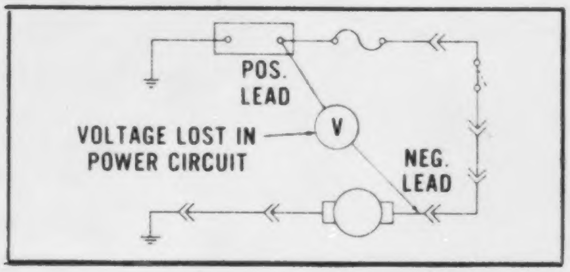
If the ground circuit also had a poor connection that dropped two volts, you wouldn't see it with the test we just described. The 10 volts that the meter is indicating is the voltage used by the rest of the circuit. As you can see from the example below, the motor really has only about 8 volts to work on, since 4.5 volts are being dropped or used up at other places in the circuit. This brings up an important testing principle.



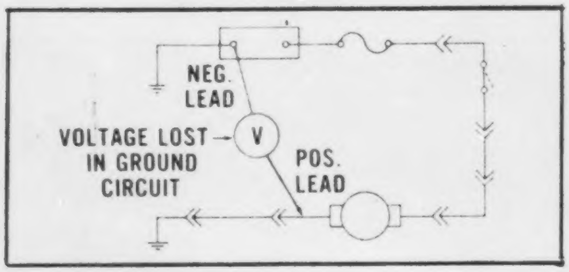
If you connect a voltmeter into a circuit between any given point and ground without interrupting the circuit by breaking a connection, you'll measure the amound of voltage that's used by the rest of the circuit. This includes the entire path of power back to the battery through the ground cable. This reading isn't really meaningful, since it doesn't tell you anything about how much voltage is being lost. It simply tells you how much is used.



The best way to test for voltage drop is to connect a voltmeter in parallel with the circuit to the operating component. One probe of the voltmeter is connected to the battery while the other probe is inserted into the wire at the point being tested.



To test the voltage drop in the power feed to a component, connect the positive lead of the voltmeter to the positive post of the battery and insert the negative lead into the wire at the point you want to test. Remember, however, to leave the circuit connected and to perform the test while trying to operate the component. The meter will indicate the amount of voltage lost, or dropped in the power circuit.



To test for voltage drop in the ground circuit to a component, first connect the negative lead of the voltmeter to the negative post of the battery. Then insert the positive lead into the wire at the point you want to test. The meter now, will indicate the amount of voltage lost in the ground circuit of the motor.

ANY TOTAL VOLTAGE DROP OVER 1.3 VOLTS IS UNACCEPTABLE.

MAXIMUM ALLOWABLE VOLTAGE DROP UNDER LOAD

When you are checking for high resistance in a circuit, it's a good idea to start right at the battery. There may be more than one high resistance point in the circuit, and they have a cumulative effect. You can leave the voltmeter positive lead connected to the positive terminal and move the negative lead to various test points in the circuit until you isolate the problem.

The voltage drop should not be more than listed in the table.

BATTERY TO . . .	MAX. VOLTS
Fuse panel	.7
Ignition switch	.7
Headlight switch	.7
Load	1.3
Ignition coil Battery terminal (ignition switch in start position)	.5 (critical)

The Relationship of Voltage Drop to Circuit Load and Voltage Measurement

Discussion will verify the following rules.

Rule 1. Bad connection resistance in automotive circuits cannot be measured with a typical ohmmeter.

Rule 2. If current flow in a circuit increases, voltage drop will also increase.

Rule 3. If current flow in a circuit decreases, voltage drop will also decrease.

Rule 4. A voltmeter alone across a circuit with a bad connection will not measure voltage drop.

Rule 5. Always measure for voltage drop with the circuit complete and under load (current flowing.)

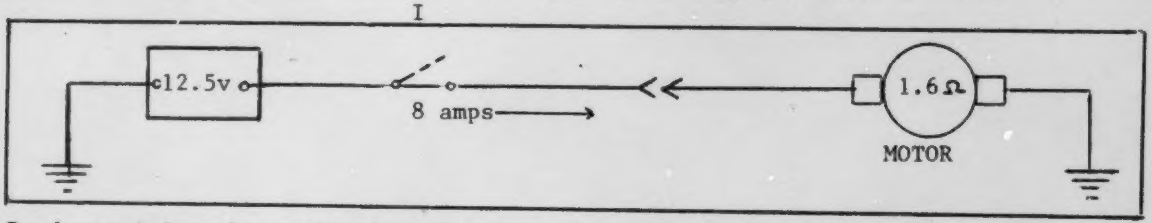
To recognize the relationship of voltage drop to current draw, we need to consult Ohm's Law and the rules pertaining to current flow in a series circuit.

Ohms Law is $E = I \times R$, $I = \frac{E}{R}$, and $R = \frac{E}{I}$

Where: E = voltage
I = current
R = resistance

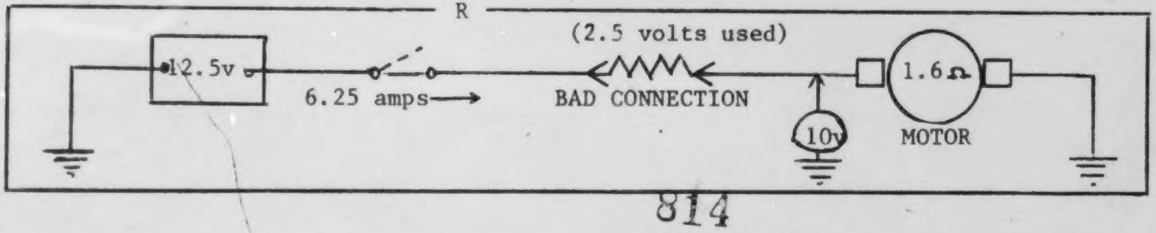
In a series circuit current flow remains the same through all parts of the circuit.

Using our previous circuit example of a motor, we'll assume the normal current draw to be 8 amperes. The voltage was 12.5 volts. To calculate normal motor internal resistance we use $R = \frac{E}{I}$ E=12.5 volts, I=8 amps, R=about 1.6 ohms



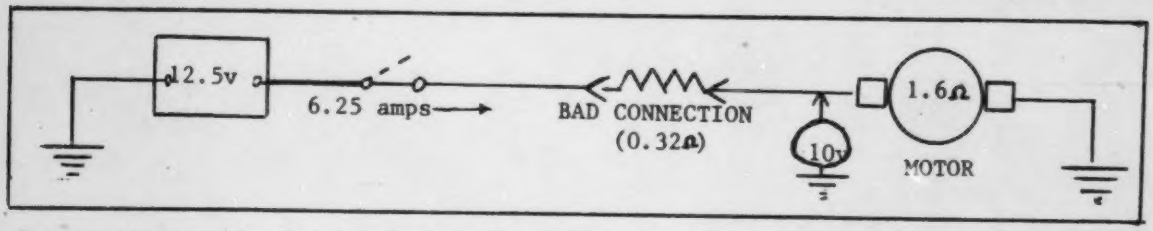
By determining the available voltage at the motor while it is operating,we previously found a voltage drop before the motor of 2.5 volts. Using the 10 volt figure at our motor, we can now calculate a new current draw for the circuit.

We can expect a lower value for current because the resistance due to a bad connection restricts current flow to the motor. (An infinite amount of resistance is the same as an open circuit and would restrict all current flow.) To find our new current amount, we'll use $I = \frac{E}{R}$, R=1.6Ω and E=10 volts. The new I is 6.25 amps.



Since the current flow is the same in all parts of the circuit, we can use our new I value to calculate the amount of resistance at our bad connection.

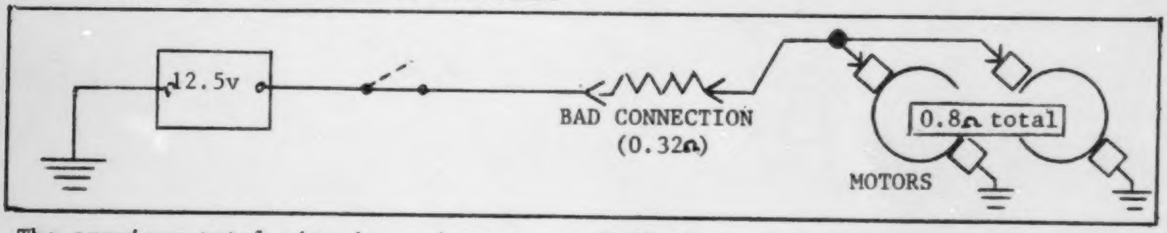
We know the amount of voltage use by the bad connection (2.5v) so we can find R by using $R=\frac{E}{I}$, E=2.5 volts, I=6.25 amps. R=about 0.32 Ω


12.5v
6.25 amps
BAD CONNECTION
(0.32Ω)
10v
1.6Ω
MOTOR

As you can see the bad connection has very little actual resistance. It has such a great effect on this circuit due to the low voltages being used. This brings about rule 1.

Rule 1. Bad connection resistance in automotive circuits cannot be measured with a typical ohmmeter.

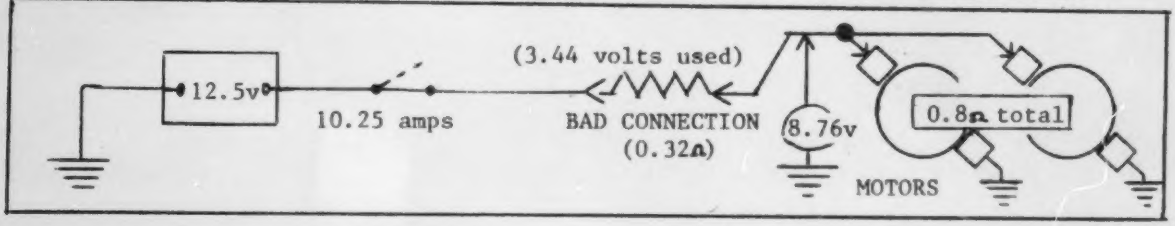
Now lets find out what happens in our circuit if current draw is increased. For this example, we'll add a second motor in parallel after the bad connection. Both motors will have equal internal resistance of 1.6 ohms. Using our formula for resistors in parallel, (product of resistors divided by sume of resistors) we get a new total resistance of 0.8 ohms.


12.5v
BAD CONNECTION
(0.32Ω)
0.8Ω total
MOTORS

The previous total circuit resistance was 1.92 ohms. Our new total circuit resistance is 1.12 ohms.

To find out our new current draw amount we will use $I=\frac{E}{R}$, E=12.5 volts, R=1.12 ohms. I now equals 10.75 amps.

To find out what our new voltage drop is we will use E=IXR, I=total current=10.75 amps, R=bad connection resistance=0.32 E=voltage drop at bad connection=3.44 volts

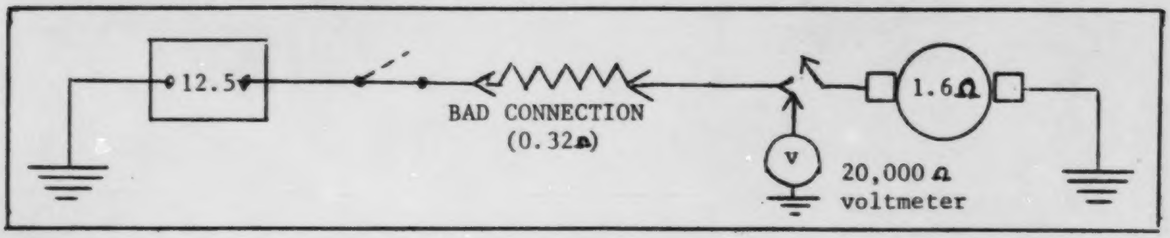

12.5v
10.25 amps
(3.44 volts used)
BAD CONNECTION
(0.32Ω)
8.76v
0.8Ω total
MOTORS

This brings about rule 2.

Rule 2. If current flow in a circuit increases, voltage drop will also increase.

Next we'll discover why voltage drop will decrease as the current draw decreases. For this circuit, we'll remove the low resistant load and install one with very high resistance (in this case a voltmeter). Our voltmeter has a 0-20 volt range with a 1000 ohms per volt resistance rating, e.i., 20,000 ohms.

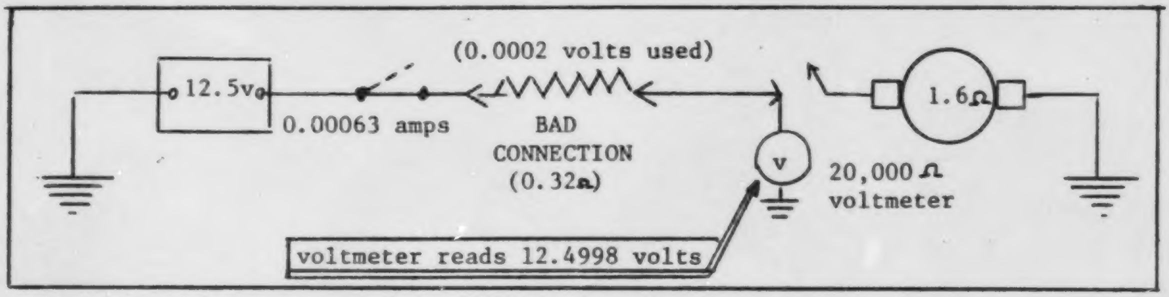
When installed across the circuit in place of the motors it will read 12.5 volts. If one motor were connected, it would read 10 volts. Why? For the answer to this question, let's examine the circuit.


12.5v
BAD CONNECTION
(0.32Ω)
1.6Ω
v
20,000 Ω
voltmeter

The previous total circuit resistance was 1.92 ohms. Our new total circuit resistance is 20,000,.32 ohms.

To find out our new current draw amount, we will use $I=\frac{E}{R}$, E=12.5 volts, R=20,000 .32 ohms. I now equals 0.00063 amps.

To find out what our new voltage drop is we will use E=IXR, I=total current= 0.00063 amps, R=bad connection resistance=0.32 E=voltage drop at bad connection= 0.0002 volts.


(0.0002 volts used)
12.5v
0.00063 amps
BAD
CONNECTION
(0.32Ω)
v
1.6Ω
20,000 Ω
voltmeter
voltmeter reads 12.4998 volts

This brings about rules 3, 4, and 5.

Rule 3. As current draw decreases, voltage drop decreases.

Rule 4. A voltmeter alone across a circuit with a bad connection will not measure the voltage drop.

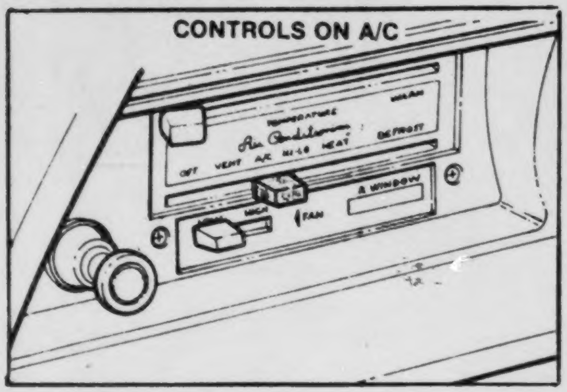
Rule 5. (For Summary) Always measure voltage drop with the circuit complete and under load.

Voltmeter Testing for Voltage Drop

Problem #1 - Air Conditioning Clutch Doesn't Engage.

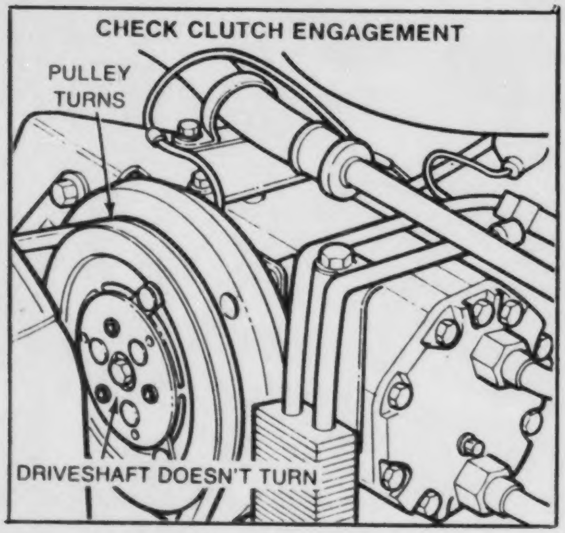
In this problem, the customer has complained of no cool air from the air conditioning. The service advisor has noted on the R.O. that the compressor clutch is not engaging and routed the repair to electrical diagnosis. This time, we're dealing with a slightly more complex circuit, but the diagnosis is still very simple to do.

Step 1. Verify the Complaint.


CONTROLS ON A/C
TEMPERATURE
WARM
Air Conditioning
OFF
VENT
A/C
HI-LO
HEAT
DEFROST
HIGH
FAN
R WINDOW

Again, begin by determining the problem. The A/C clutch should engage with a loud click when the control is set for A/C and the ignition switch is in the RUN position.

If you don't hear the clutch pull-in and click, start the engine and open the hood to check it visually.


CHECK CLUTCH ENGAGEMENT
PULLEY TURNS
DRIVESHAFT DOESN'T TURN

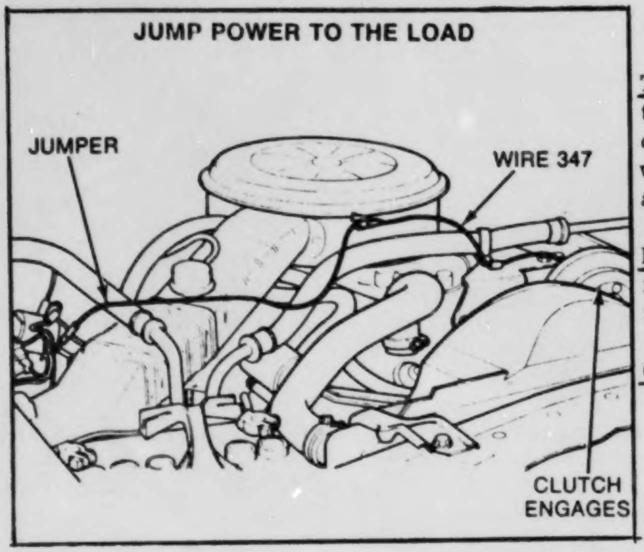
Check the drive pulley on the air conditioning compressor. It is being driven by the engine belt.

However, the clutch is not "pulled in" and the compressor driveshaft is not turning; so we have determined that there is a problem.

Step 2. Define the Type of Problem

Since we have no apparent clutch operation, either the solenoid that pulls the clutch in is bad, or the circuit that energizes the clutch is open somewhere.

(At this point, most experienced troubleshooters would jump power to the clutch to find out which it is; a slight variation in the 7-step order.



Test A. Separate the bullet connector that connects the feed wire to the compressor clutch. Connect a jumper wire between the clutch lead terminal and the starter relay main feed terminal.

RESULTS. The clutch fails to pull in, or it will not drive the compressor with the engine running.

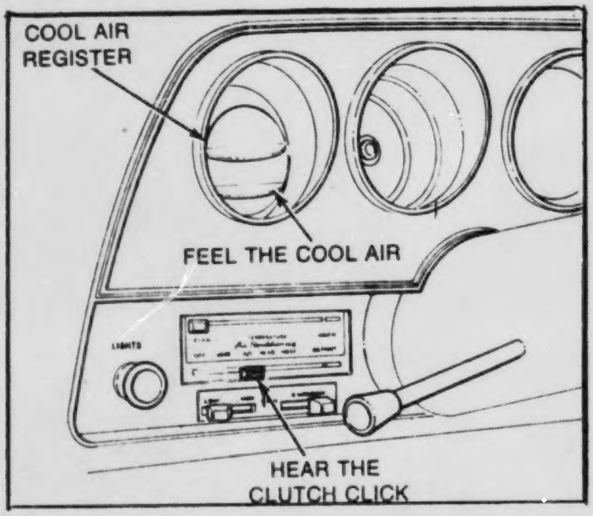
CONCLUSION. The clutch unit is at fault.

At this point, we can bypass steps 3, 4, and 5 and proceed to Step 6.

Step 6. Repair

Repairing the clutch is a mechanical job. You replace the clutch and its burnt out solenoid pull in winding.

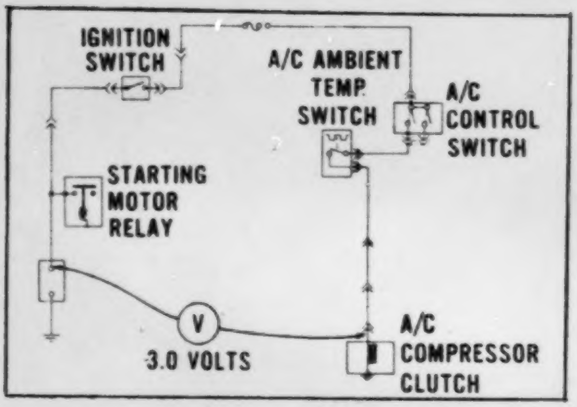
Step 7. Test the repair



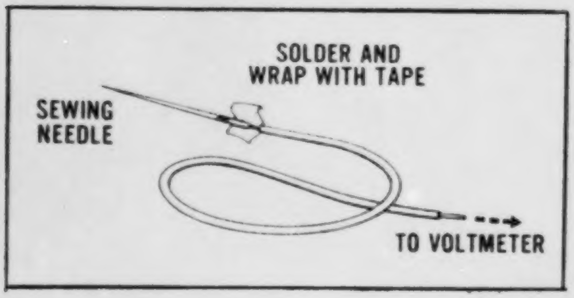
To test the repair, check that the clutch clicks in when you operate the controls. To verify clutch drive, check for cold air from the A/C registers.

In this situation, the clutch clicks in and you get proper cooling. You're all done, right?

Well, wait a minute! What if that clutch failed because of voltage drop. What if the applied voltage to the solenois was so low that it had to work extra hard to do its job? Maybe we'd better check just to be sure. It won't take but a minute. To find out, we'll use a voltmeter with a 0-3 volt range.



Test A. Connect the positive voltmeter lead to the positive post of the battery and the negative lead to the power feed running to the clutch. This will parallel the entire circuit to the clutch and will tell us if we've got an excessive voltage drop.



(To make it a little easier to pierce the insulation of the wire, we've come up with a handy tool. It's simply a sewing needle soldered to a piece of wire, and then partially covered with electrical tape. We'll insert the needle end of the tool into the wire (at an angle) at the clutch and connect the other end of the wire to the alligator clip on the negative lead of the voltmeter.)

Remember now, that we're performing this check while trying to operate the clutch, that is with all of the A/C controls in their proper positions.

RESULTS. Our voltmeter reads 3 volts.

CONCLUSION. This reading is way too high. The reading is so high in fact that it might cause the new clutch to fail. We had better repair it.

Step 3. Isolate the Problem.

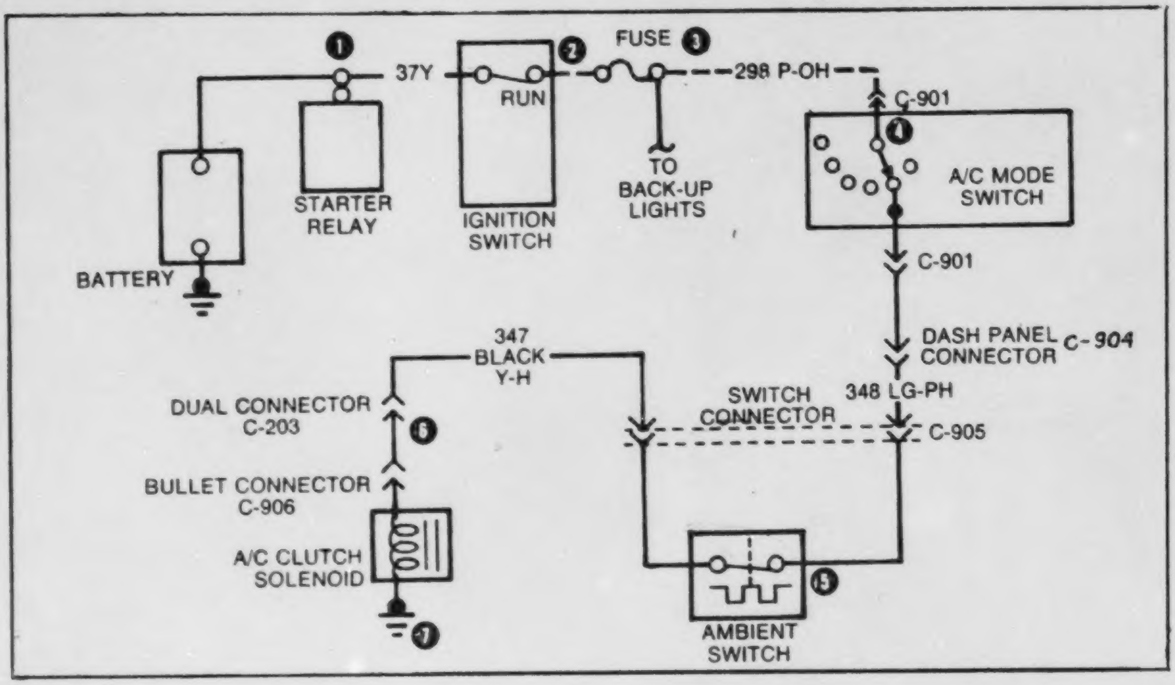
To diagnose this problem, we'll begin with step 3. Isolate the Problem. Our first need is trace the circuit on a wiring diagram. This will aid us in locating possible test points.

1. The circuit begins at the battery, and through the positive cable to the main feed terminal of the starter relay. From there, wire 37-yellow carries power to the ignition switch to feed the circuits that are ignition-hot. By ignition-hot, we mean the ignition switch must be in the accessory run position to complete the circuit.

2. With the ignition switch in the run position, power continued to the A/C clutch fuse.

3. The fuse-out terminal is a common point. On this vehicle, the A/C clutch fuse also feeds the back-up lights. The circuit continues through wire 298 P-OH (pink with orange hash marks) to the A/C mode switch on the control head; through the switch connector C-901.

Notice that wire 298 is drawn by a dashed line. A heavy dashed line on the schematic indicates that the circuit is fed through the ignition switch.


❶
37Y
❷
FUSE ❸
298 P-OH
RUN
C-901
❹
TO BACK-UP LIGHTS
A/C MODE SWITCH
STARTER RELAY
IGNITION SWITCH
BATTERY
C-901
DASH PANEL CONNECTOR
C-904
347 BLACK Y-H
348 LG-PH
DUAL CONNECTOR C-203
❻
SWITCH CONNECTOR
C-905
BULLET CONNECTOR C-906
A/C CLUTCH SOLENOID
❺
AMBIENT SWITCH
❼

4. With the mode switch in the A/C position, power continues through C-901 again, and now via wire 348 (green) through the dash panel connector to C-905 at the ambient switch.

5. The ambient switch is closed if the outside air is above 40 degrees or so; otherwise it opens to protect the compressor. Power continues through the switch, back to connector C-905, and then via wire 347 (black) to the clutch solenoid.

6. On the way to the clutch solenoid, the black wire goes through a dual connector C-203 on the left side of the engine compartment; and then through a bullet connector near the clutch.

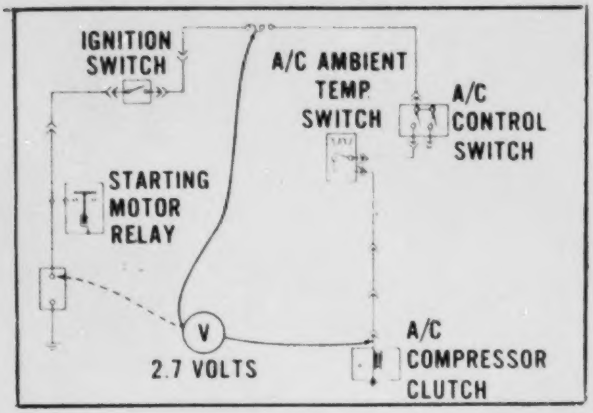
7. The compressor clutch is self-grounded on York and Tecumseh compressors.

FRIGIDAIRE COMPRESSOR. If the vehicle has a Frigidaire compressor, there is a ground wire (57 black). Instead of the bullet connector, then, there is a dual connector that plugs into the compressor.

Since the high resistance point could be anywhere in this circuit, our isolation must continue with actual testing.

Step 4. Test Systematically

We begin our testing by dividing the circuit in half. As the fuse is about halfway through the circuit, we select this as our test point.

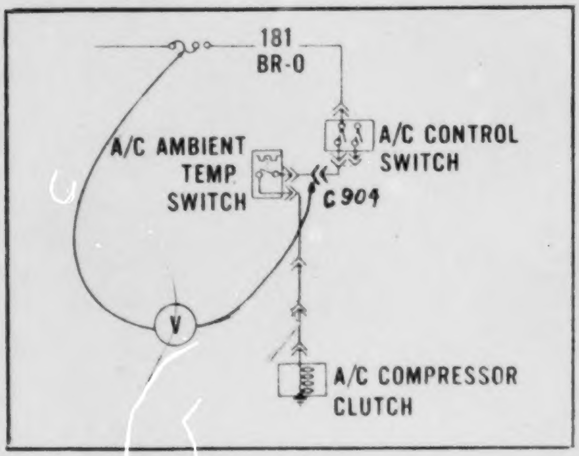

IGNITION SWITCH
A/C AMBIENT TEMP SWITCH
A/C CONTROL SWITCH
STARTING MOTOR RELAY
V
2.7 VOLTS
A/C COMPRESSOR CLUTCH

Test B. Leaving the voltmeter connection intact at the clutch feed wire, move the other lead to the fuse terminal.

RESULT. Voltmeter reads 2.7 volts.

CONCLUSION. The voltage drop is between the fuse and the clutch.

To find out where, we'll simply move the voltmeter leads closer together. Checking the wiring diagram, we note that connector C-904 is the dash panel connector (firewall).

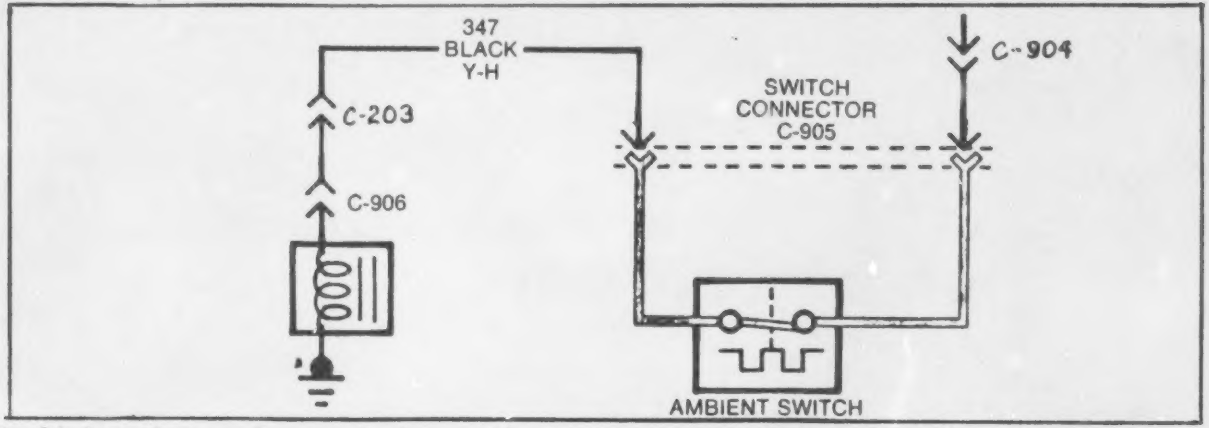

181
BR-O
A/C AMBIENT TEMP SWITCH
A/C CONTROL SWITCH
C 904
V
A/C COMPRESSOR CLUTCH

Test C. Move the voltmeter test lead that was at the clutch to terminal 348 (light green/purple hash wire) of the dash panel connector.

RESULT. Voltmeter reads only 0.2 volts.

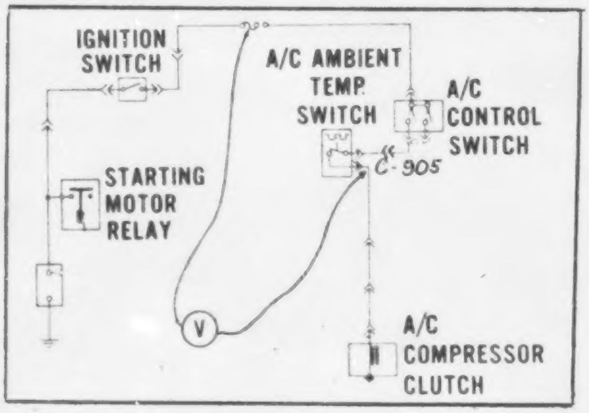
CONCLUSION. The high resistance is not in the section of the circuit between the voltmeter leads. It must be between the dash panel connector C-904 and the clutch.

We have further isolated our problem and we find that it is located within the engine compartment area. The wire diagram for this section is shown below.


347
BLACK
Y-H
C-904
SWITCH
CONNECTOR
C-905
C-203
C-906
AMBIENT SWITCH

Realizing that we bypassed the problem point, we can do one of two test hookups. First, we can move our fuse connection to the test point at C-904 and move our needle probe back along the circuit toward the clutch. Second, we can retain our test hookup at the fuse and only move the needle probe back toward the clutch. When we do the latter, we have to discount the 0.2 volt reading in order to obtain the actual drop between C-904 and the further test point.

We elect to do the second test in this case because it involves only moving one test point.


IGNITION
SWITCH
A/C AMBIENT
TEMP
SWITCH
A/C
CONTROL
SWITCH
C-905
STARTING
MOTOR
RELAY
V
A/C
COMPRESSOR
CLUTCH

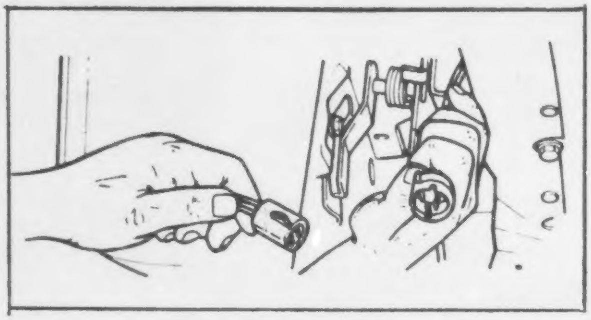
Test D. Move the voltmeter connection that was at connection C-904 back along the circuit toward the clutch. Insert the test lead at the 347 (black-yellow hash) wire in connection C-905.

RESULTS. Voltmeter reads 2.6 volts.

CONCLUSION. The voltage difference of 2.4 volts occurs in the circuit segment from connector C-904 to the clutch side of connector C-905.

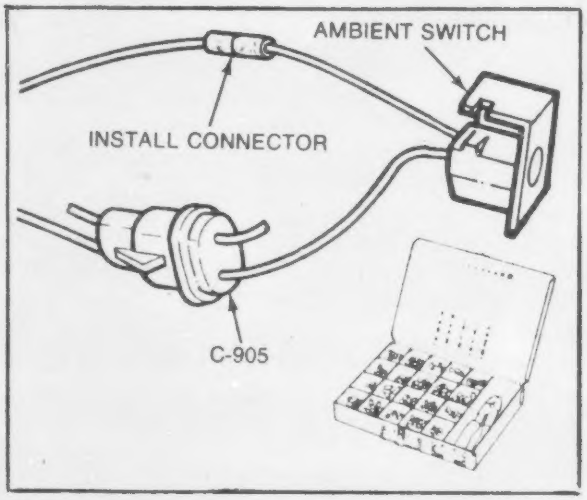
The problem area from this test is the ambient temperature switch and its connector. Let's check it out.

Step 5. Verify the problem.



At this point, we suspect a defective switch or a bad connector. Opening the connector, we find a badly burned and loose terminal.

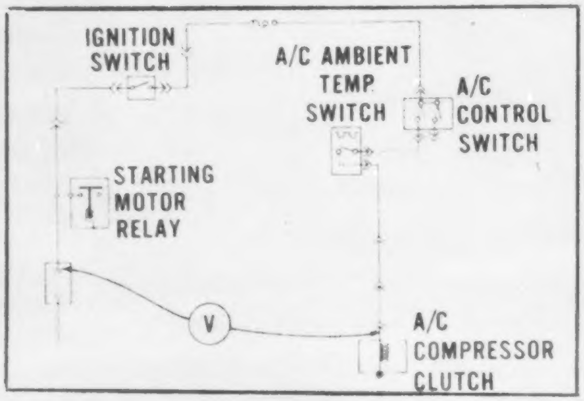
Step 6. Repair


AMBIENT SWITCH
INSTALL CONNECTOR
C-905

To repair the circuit, snip the wire on both sides of the connector. Install male and female ends of a single-wire spade or bullet connector and snap them together. If it's an exposed-terminal connector, tape it up to prevent a short.

Leave the other wires attached to C-905 and snap it back together. (Test the repair before re-installing the switch on the support brace.)

Step 7. Test the Repair


IGNITION SWITCH
A/C AMBIENT TEMP SWITCH
A/C CONTROL SWITCH
STARTING MOTOR RELAY
V
A/C COMPRESSOR CLUTCH

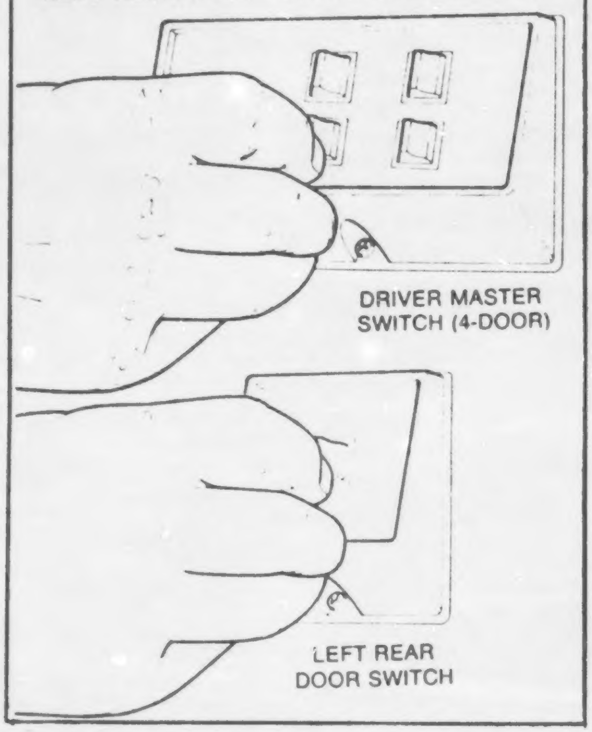
To test this repair, we repeat our original voltage drop test. This time our voltmeter reads less than 1 volt making this circuit acceptable.

Voltmeter Testing for Voltage Drop

Problem #2 - Slow power window

Step 1. Verify the Complaint

LEFT REAR POWER WINDOW CONTROLS



The ignition switch must be in the ACCESSORY or RUN position to operate the power windows. Also, the battery must be reasonably charged.

We first try the left rear window from the master switch on the driver's door. It goes up and down smoothly and at normal speed.

Then we operate it from the switch in the passenger door. It does run slow, both up and down, from the rear switch. Problem verified.

Step 2. Define the type of problem

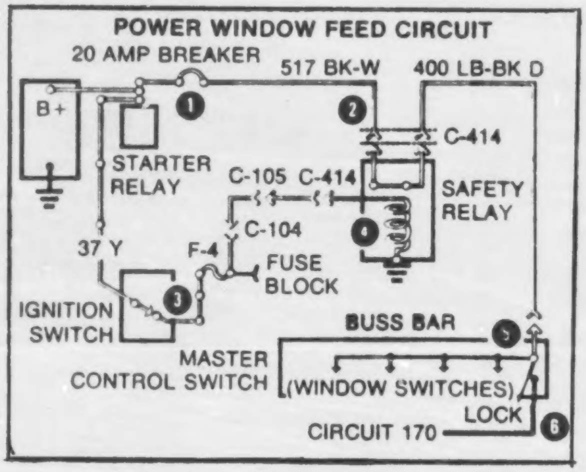
The three causes of slow motor operation are:

1. excessive circuit voltage drop
2. mechanical bind
3. defective motor

During our complaint verification we found the window to operate normally from the drivers door master switch. From this, we can eliminate the mechanical bind problem and the defective motor problem. There is definitely a voltage drop in the circuit.

Step 3. Isolate the problem

In this motor circuit, the voltage drop offers us an opportunity to see its effects. As a result, we can treat it like an open circuit when doing our problem isolation. Our first step would be to locate a first common point with the power circuit to the left rear window. Since this is a complicated circuit, we'll trace it through entirely so you will be familiar with its operation. To simplify the presentation, the circuit is presented in segments beginning with the power feed section.


POWER WINDOW FEED CIRCUIT

1. The main power feed is through a 20- amp circuit breaker, which is attached to the starter relay main feed terminal.
2. Wire 517, black with white tracer, continues the circuit to the power window safety relay. It stops there with the ignition off.
3. When the ignition switch is turned to RUN or ACCY, and a fuse is intact . . .
4. The safety relay coil is energized and the relay closes.
5. Power continues out of the relay via wire 400, light blue with black dots, to a common point in the driver's master control switch. It feeds four window switches from a buss bar inside the master switch.
6. If the driver puts the LOCK switch in the unlock or closed position, power also continued to circuit 170. This circuit feeds the switches in the other doors.

If the lock switch is open, the switches in the other doors will not operate the windows.

7. Wire 170, red with light blue dots, continues from the master switch to a splice S-402. This is in the wiring harness in the driver's door. It splits to two leads at the splice.

8. One lead goes from the splice to the right front door switch. The other goes to the left rear door switch.

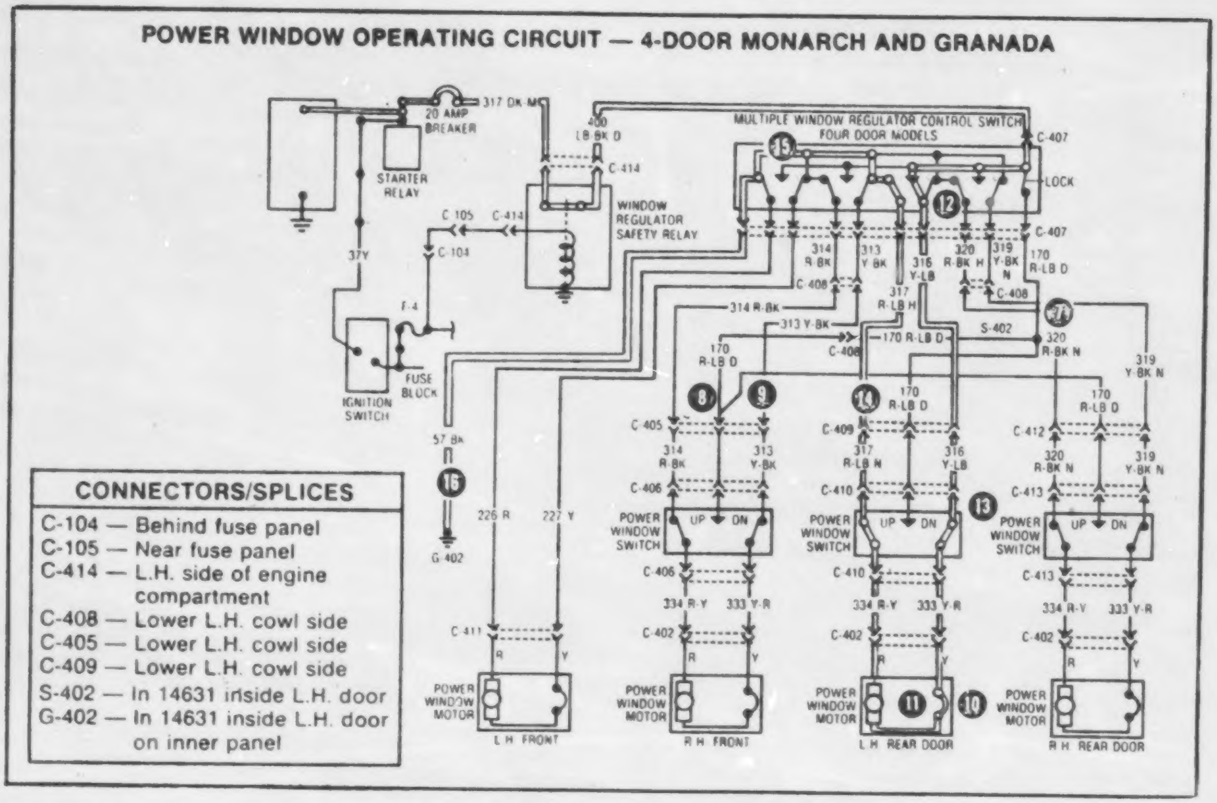
9. At the right front door switch connector, wire 170 splits again to take power to the right rear door switch.

In addition to wire 170, each of the door switches has a red and a yellow lead that connects the power window motors directly to the master switch.

10. The motors are reversible. When the red lead is hot, the yellow lead is grounded, and the motor cranks the window down. Reverse the switch, and the window cranks up.

11. Each motor is equipped with a circuit breaker that will open the circuit in either direction if:
- The motor stalls due to a mechanical bind, or . . .
- The switch is held closed when the window is at the end of its travel.

Except for the driver's window, the power windows operate from either of two switches. To help isolate this problem, let's look at the operation of our problem window from both switches.



POWER WINDOW OPERATING CIRCUIT — 4-DOOR MONARCH AND GRANADA

20 AMP BREAKER
317 DK M
STARTER RELAY
37Y
C 105
C-414
C-104
F-4
FUSE BLOCK
IGNITION SWITCH
400 LB-BK D
C-414
WINDOW REGULATOR SAFETY RELAY
MULTIPLE WINDOW REGULATOR CONTROL SWITCH FOUR DOOR MODELS
C-407
LOCK
15
12
314 R-BK
313 Y-BK
316 Y-LB
320 R-BK H
319 Y-BK N
170 R-LB D
C-408
317 R-LB H
S-402
17
170 R-LB D
C-406
57 BK
16
G-402
226 R
227 Y
8
9
14
13
10
11
C-405
C-409
C-412
C-410
C-413
POWER WINDOW SWITCH
UP
DN
334 R-Y
333 Y-R
C-411
C-402
R
Y
POWER WINDOW MOTOR
L H FRONT
R H FRONT
L H REAR DOOR
R H REAR DOOR

CONNECTORS/SPLICES

C-104 — Behind fuse panel
C-105 — Near fuse panel
C-414 — L.H. side of engine compartment
C-408 — Lower L.H. cowl side
C-405 — Lower L.H. cowl side
C-409 — Lower L.H. cowl side
S-402 — In 14631 inside L.H. door
G-402 — In 14631 inside L.H. door on inner panel

Up From Master Switch

To raise the window from the driver control:

12. The master switch buss bar connects power to wire 316, yellow with light blue tracer, to the switch in the rear door.

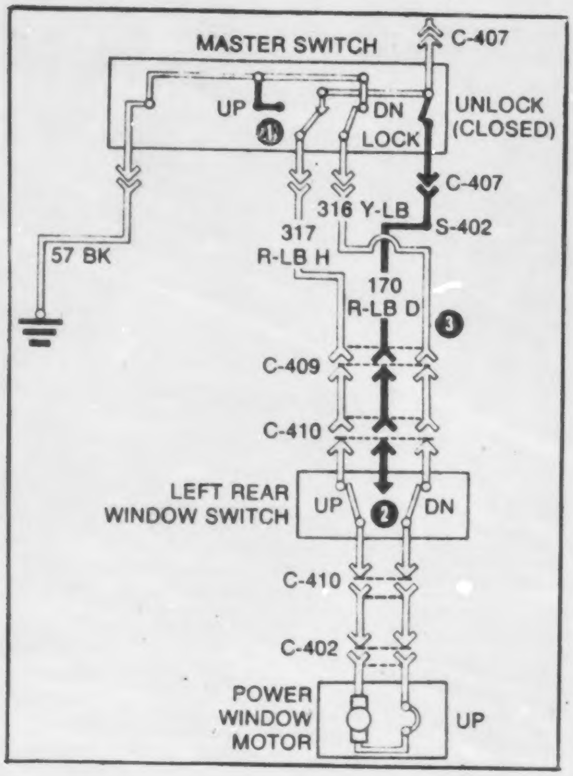
13. The rear door switch is in the off (neutral) position, and power continues through contacts in the switch to the motor assembly.

14. The opposite wire 317, red with light blue hash marks, forms the return or ground path back to the master switch.

15. In the switch, a ground buss bar continues the circuit to the ground wire 57 black.

16. Wire 57 is grounded at G-402 in the driver's door.

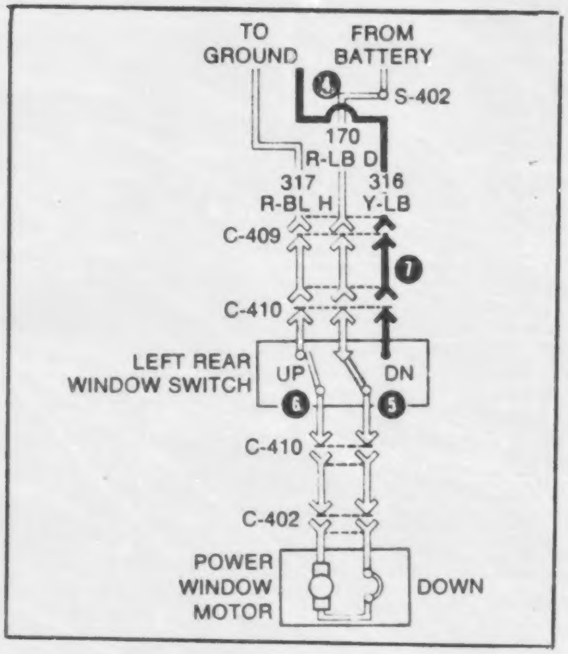
This is one of the few two-wire circuits in the car. No matter which way the windows operate, they are grounded through the master switch.


MASTER SWITCH
C-407
UP
DN
LOCK
UNLOCK
(CLOSED)
1
C-407
316 Y-LB
S-402
317
R-LB H
57 BK
170
R-LB D
3
C-409
C-410
LEFT REAR
WINDOW SWITCH
UP
2
DN
C-410
C-402
POWER
WINDOW
MOTOR
UP

Down from Master Switch

To lower our "problem" window from the master switch:

1. The switch is reversed from the down position, so that red wire 317 is hot.
2. The rear door switch remains in "neutral" and continues the hot circuit to the motor.
3. Yellow wire 316 is the return path to the master switch and to the ground buss bar.


TO
GROUND
FROM
BATTERY
4
S-402
170
R-LB D
317
R-BL H
316
Y-LB
C-409
7
C-410
LEFT REAR
WINDOW SWITCH
UP
DN
6
5
C-410
C-402
POWER
WINDOW
MOTOR
DOWN

Passenger Switch Operation

When the window is operated from the passenger switch, the master switch is in neutral, and all the leads to the motors are connected to the ground buss bar.

4. Remember that wire 170 is hot from the master switch to the passenger door switch in the unlock position.

Up From Passenger Switch

5. The switch connects the yellow wire to the motor to the hot terminal of wire 170.
6. The red wire completes the ground circuit back to the master switch.
7. The yellow wire is not hot between the switches. It is grounded in the master switch.

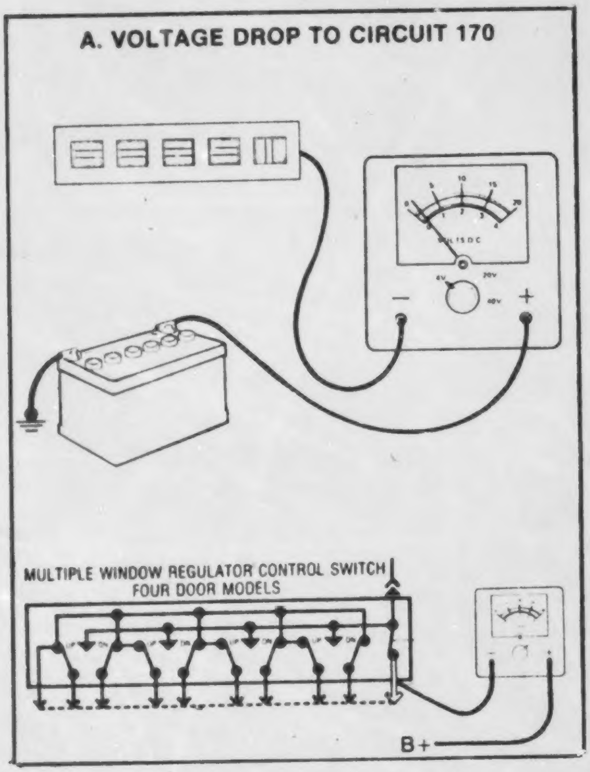
Step 4. Test Systematically

We have concluded that there is high resistance in circuit 170 to the left rear door switch. To pinpoint it, we want to make voltage drop tests. And we'll observe two rules to make the job easier:

- Test at the most convenient places first.
- Don't remove a door trim-panel until you absolutely must.

It is very easy to sneak a probe behind a master power window switch and connect a voltmeter lead to the terminals for wire 170.

So we'll connect the voltmeter positive lead to the battery positive terminal and touch the negative lead to our test points to read voltage drop.

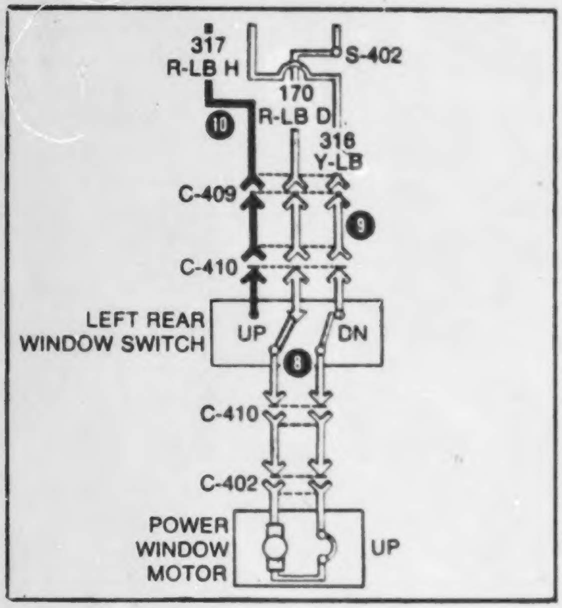

A. VOLTAGE DROP TO CIRCUIT 170

Test A. Touch the negative probe to the farthest outboard pin behind the master switch. Operate the window up and down and read the voltage drop.

RESULTS. Less than ¼ of a volt up to circuit 170.

CONCLUSION. We expected this to be okay. However, there could have been a problem that would add to the one we're looking for. It's best to verify that this part of the circuit is okay.

To perform the same test at the rear door, we must pop out the switch and expose the connector terminals. The top left terminal is power in from wire 170. The two middle terminals are to the motor and the corner terminals are to ground in the master switch. We have inserted some sharp, clean cotter pins in the connector to operate the motor.

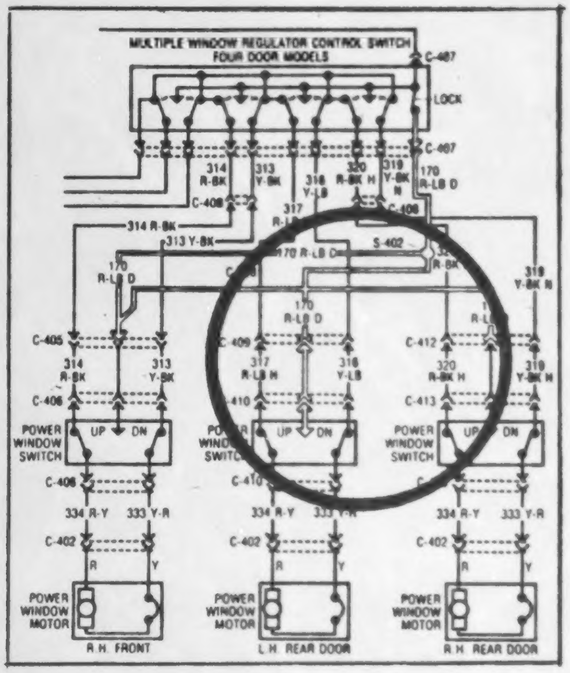

317
R-LB H
S-402
170
R-LB D
⑩
316
Y-LB
C-409
⑨
C-410
LEFT REAR
WINDOW SWITCH
UP
DN
⑧
C-410
C-402
POWER
WINDOW
MOTOR
UP

Down From Passenger Circuit

Finally, to lower the window from the rear door switch:

8. The switch contacts reverse to make the red wire to the motor hot from wire 170.
9. The blue wire is the return path back to ground at the master switch.
10. Red wire 317 is not hot between the switches. It is grounded in the master switch.

With this understanding of how current flows in the window circuit, we can quickly isolate the problem.


MULTIPLE WINDOW REGULATOR CONTROL SWITCH
FOUR DOOR MODELS
C-407
LOCK
C-407
314 R-BK
313 Y-BK
316 Y-LB
320 R-BK H
319 Y-BK N
170 R-LB D
C-408
C-408
317
314 R-BK
313 Y-BK
S-402
170 R-LB D
170 R-LB D
319 Y-BK N
C-405
C-409
C-412
314 R-BK
313 Y-BK
317 R-LB H
316 Y-LB
320 R-BK H
319 Y-BK H
C-406
C-410
C-413
POWER WINDOW SWITCH
UP
DN
C-406
C-410
334 R-Y
333 Y-R
C-402
R
Y
POWER WINDOW MOTOR
R.H. FRONT
L.H. REAR DOOR
R.H. REAR DOOR

Use Logic

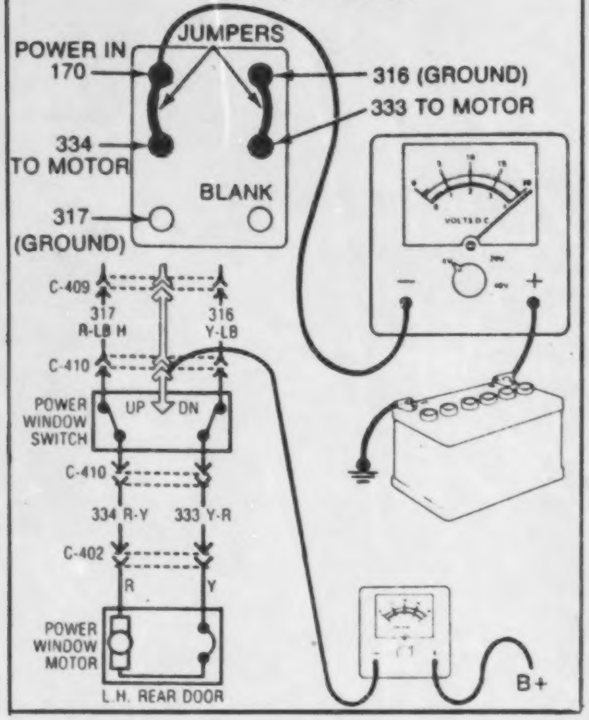
We have already decided that the window motor is okay and that there's no mechanical bind.

We can deduce farther that, since the window worked okay from the driver switch, wires 316 and 317 must be in good shape from the master switch to the motor.

Also, the ground circuit must be okay.

CONCLUSION 1. The problem must be in circuit 170 between the master switch and the rear switch.
Can we isolate it further? Well, remember that wire 170 is common to the right hand window circuits as well up to splice S-402. So we'll operate the right hand windows from the passenger switch. And they both work fine.
CONCLUSION 2. Circuit 170 is okay up to S-402. The problem must be somewhere between S-402 and the rear door switch, or the switch itself. We will test for high resistance in the part of circuit 170 circled in gray.

B. VOLTAGE DROP THROUGH CIRCUIT 170 TO DOOR SWITCH

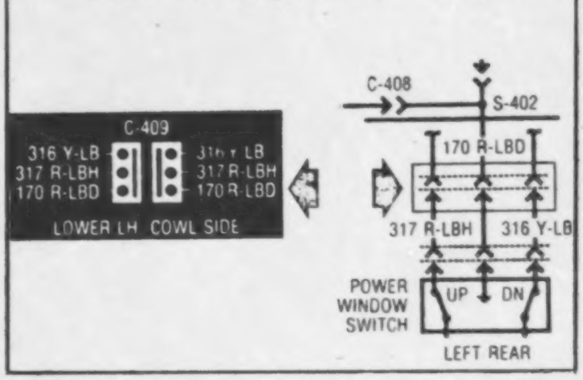

POWER IN
170
JUMPERS
316 (GROUND)
333 TO MOTOR
334
TO MOTOR
BLANK
317
(GROUND)
VOLTS D.C.
−
+
C-409
317
R-LB H
316
Y-LB
C-410
POWER
WINDOW
SWITCH
UP
DN
C-410
334 R-Y
333 Y-R
C-402
R
Y
POWER
WINDOW
MOTOR
L.H. REAR DOOR
B+

Test B. Move the voltmeter negative lead to the wire 170 terminal. Use jumpers between cotter pins to ground one of the motor terminals and make the other hot to raise and low the window. Read the voltage drop both ways.

RESULTS. The meter reads over 4 volts. It should not be more than .7 volts.

CONCLUSION. The high resistance condition in circuit 170 is verified. To pinpoint it, we'll look for another convenient test point.

LOCATING MULTIPLE CONNECTOR

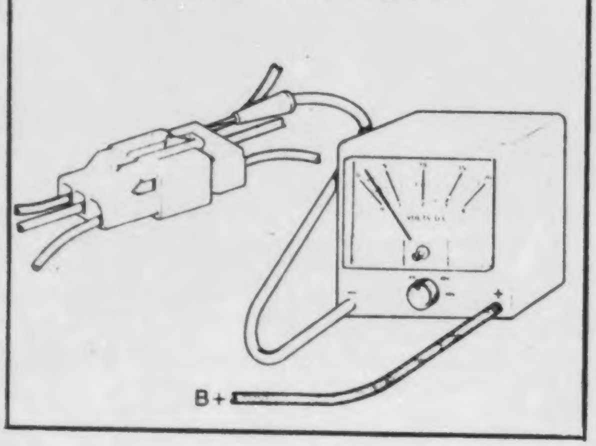

C-409
316 Y-LB
317 R-LBH
170 R-LBD
316 Y-LB
317 R-LBH
170 R-LBD
LOWER LH COWL SIDE
C-408
S-402
170 R-LBD
317 R-LBH
316 Y-LB
POWER
WINDOW
SWITCH
UP
DN
LEFT REAR

Looking at the schematic, we see that wire 170 goes through a multiple connector C-409. The connector diagram says that C-409 is a gray colored, 3-wire connector, and it is located on the lower left-hand cowl side. Since it's much easier to remove a kick-pad than a door panel, we'll locate this connector and continue testing.

With the kick pad off, we notice some water streaks. It has been wet behind the pad, which could account for the problem.

We identify C-409 by its gray color and by the colors of the wires it connects. We want to test at wire 170, red with light blue dots.

C. VOLTAGE DROP TO C-409

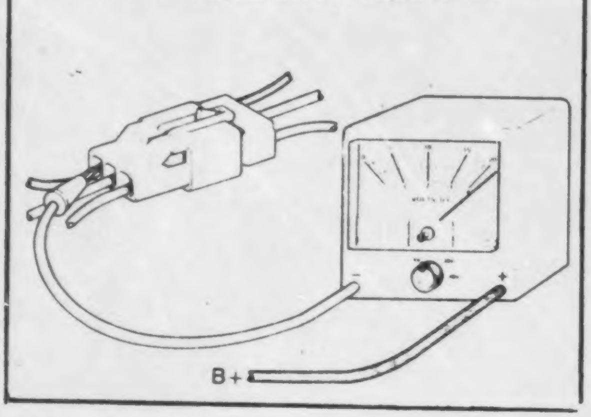


Test C. Insert the voltmeter negative probe into the connector where wire 170 enters it from the front door. Operate the window up and down from the rear switch and read the voltage drop.

RESULTS. Less than ½ volt drop.

CONCLUSION. Circuit 170 is okay going into the connector.

D. VOLTAGE DROP FROM C-409



Test D. Insert the voltmeter probe into the connector where wire 170 comes out and continues to the rear door. Again run the window up and down from the rear switch and read the voltage drop.

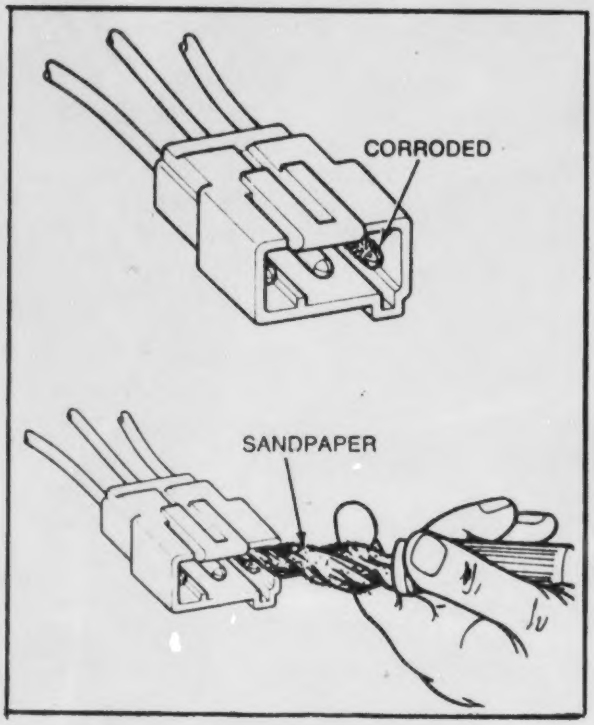
RESULTS. The needle goes full scale, more than 4 volts drop.

CONCLUSION. There is high resistance in the connector.

Step 5. Verify the cause of the Problem

To verify the problem, we open the connector and see that it has some corroded terminals. Apparently some water has gotten between the connector halves.

In such cases always be sure that the water leak has been corrected. This car had been in the shop previously for a leaky windshield, and we could see where the seal was repaired.

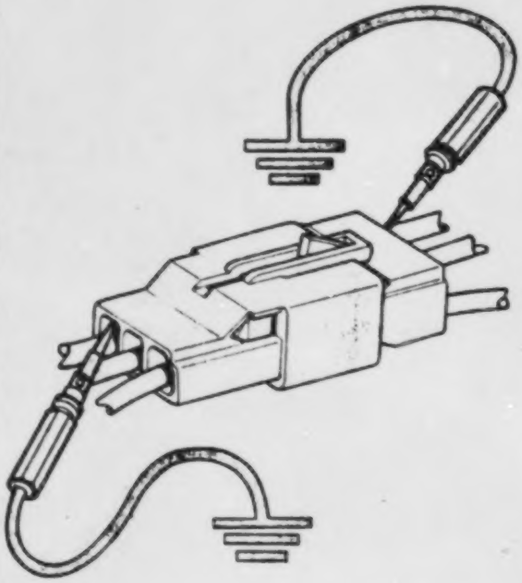


Step 6. Repair

Cleaning up the terminals with sandpaper was all that was necessary to repair this problem. Had that not fixed it, we could have snipped the wires and attached them with a new connector.

Step 7. Test the Repair

With the terminals cleaned up, we snapped the connector back together and tried the rear window. It operated okay: repair completed.



Why we couldn't diagnose this with a 12 volt test light

Suppose we had checked across this connector with a 12-volt test light instead of making a voltage drop test.

Going into the connector, the light would have glowed brightly because we had almost full battery voltage available.

Coming out, it might have glowed dimmer under load due to the voltage drop. Depending on how sharp eyed you are, you may or may not be able to tell the difference. With the meter reading voltage drop, there's no question.

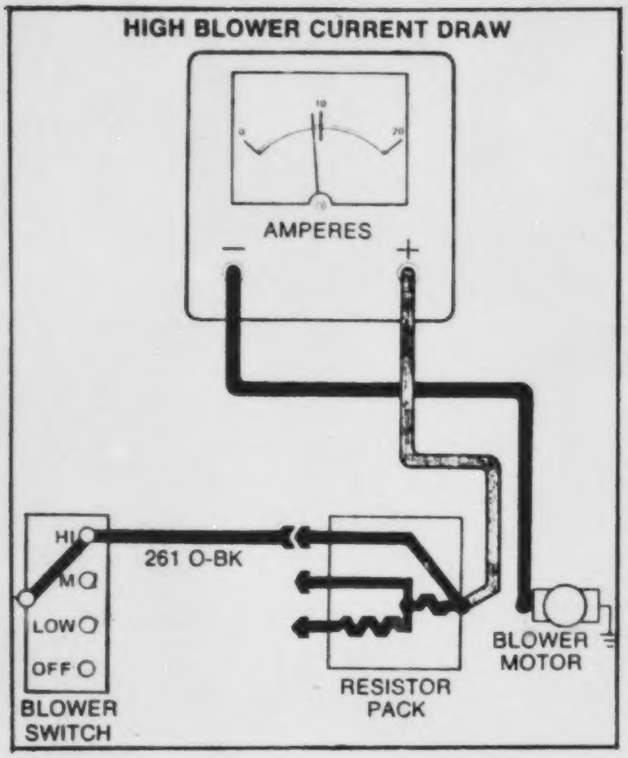
Meter Testing

Current Draw - Circuit Overload

The use of an ammeter to measure current draw were covered in Competency A-3. The following material will relate motor operation to current draw for later use in testing.

Note: The following examples are based on a heater blower circuit.

Current Draw with Full Battery Voltage available.

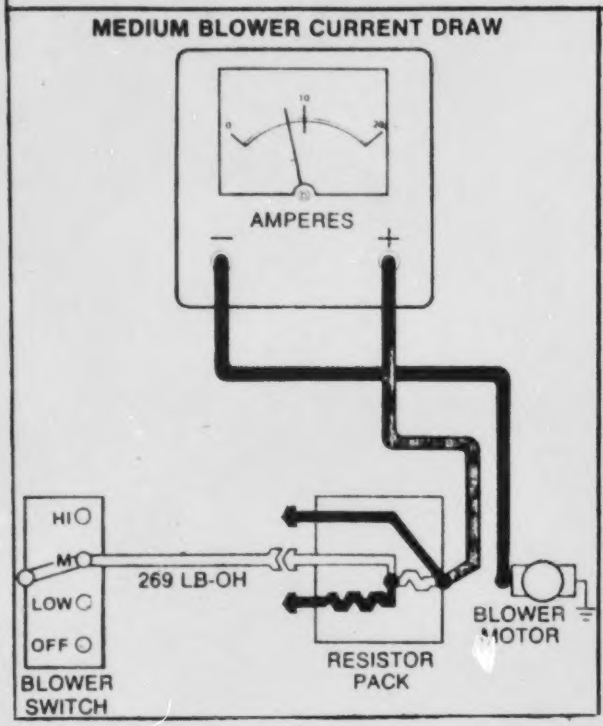

HIGH BLOWER CURRENT DRAW
0
10
20
AMPERES
−
+
HI
M
LOW
OFF
261 O-BK
BLOWER SWITCH
RESISTOR PACK
BLOWER MOTOR

In the illustration, we have connected the ammeter in series between the resistor pack and the blower motor.

The blower switch is on high, so that maximum voltage is available through wire 261.

The meter reads 8 amps, which is just about the specified current draw for some motors on high blower.

Current Draw With Speed Control (Resistance in Series)


MEDIUM BLOWER CURRENT DRAW
0
10
20
AMPERES
−
+
HI
M
LOW
OFF
269 LB-OH
BLOWER SWITCH
RESISTOR PACK
BLOWER MOTOR

When we move the switch to the medium position, we are feeding the blower through a resistor. This reduces the available voltage to the motor. It is now drawing about 6 amps, and of course, running slower.

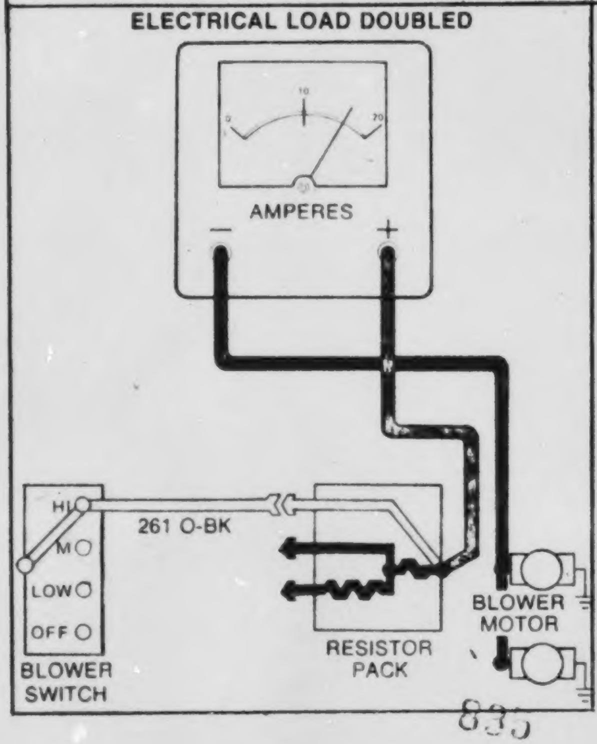
On low blower, the draw would decrease to 3 or 4 amps.

And if we turn the switch to OFF, the ammeter will read zero. (We can read voltage in an open circuit, but not current because an open circuit doesn't draw current.)

OBSERVATION . . .

Current draw is highest with no resistance, and reduces as resistances are added in series.

Current Draw With Additional Load on the Circuit


ELECTRICAL LOAD DOUBLED
0
10
20
AMPERES
−
+
HI
M
LOW
OFF
261 O-BK
BLOWER SWITCH
RESISTOR PACK
BLOWER MOTOR

Now let's see what happens to current draw when we put an additional load on the circuit.

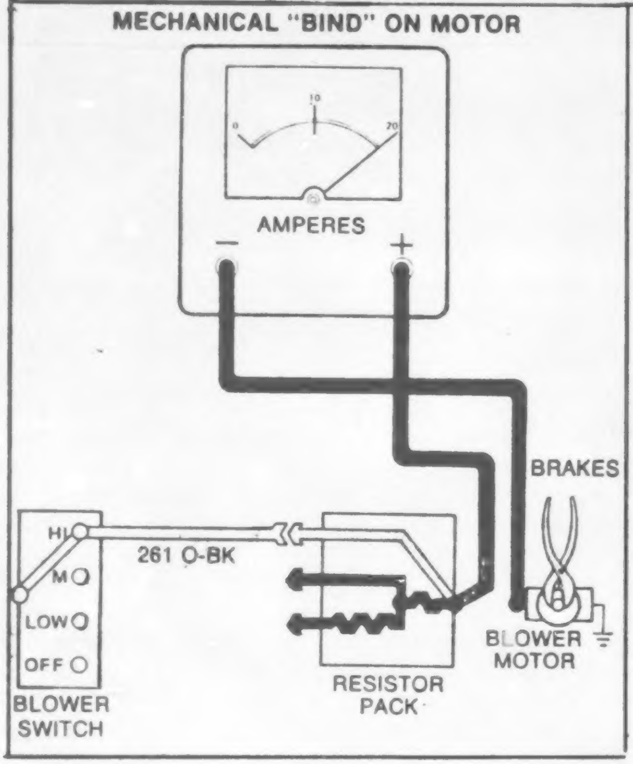
Suppose we connected a second blower motor in parallel and operate them both from the same switch on high blower.

Now, we have doubled the electrical load. The effect is to double the current draw. The meter now reads 16 amps instead of 8 amps.

OBSERVATION . . .

Whenever electrical loads are added in parallel, the current draw increases. The "effective" resistance of the circuit actually decreases as parallel loads are added. Had the two motors been connected in series, both would run at reduced speed, because one would act as a resistor for the other.

Current Draw With Mechanical Bind on Motor


MECHANICAL "BIND" ON MOTOR
0
10
20
AMPERES
−
+
BRAKES
HI
M
LOW
OFF
261 O-BK
BLOWER MOTOR
BLOWER SWITCH
RESISTOR PACK

When an electric motor or solenoid has to work harder, due to some kind of mechanical bind, it draws more current. For instance, if we "apply brakes" to the motor shaft, the current draw jumps way up. If we gripped the shaft tight enough to stall the motor, we might run the meter off the scale. The additional load, of course, will open the fuse or circuit breaker to prevent the motor from burning out.

Diagnosis Note: A bound or stalled motor will draw a great amount of current from the battery resulting in a crop of circuit voltage. This will dim lights.

OBSERVATION . . .

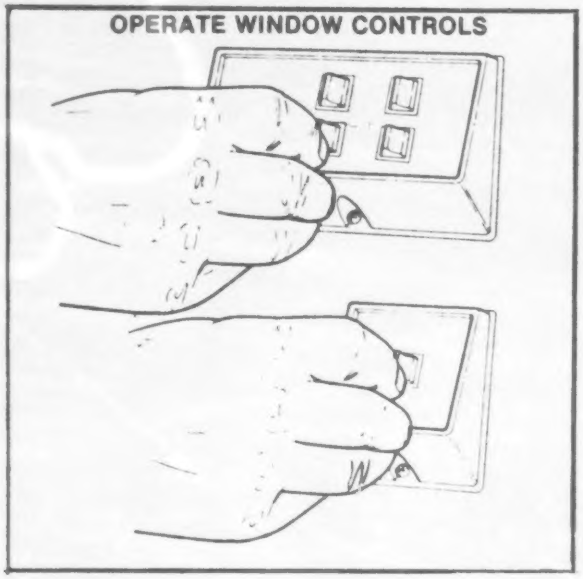
A current draw test is useful to determine if a motor is operating against a mechanical bind.

Meter Testing for Current Draw

Problem #1. Power window runs slow and stops.

On a 1975 Granada 4-door, the customer complains that the left rear window runs slow and stops. This is a similar problem to the one covered under Voltage Testing (Information Sheet #5), but with a different kind of cause.

Step 1. Verify the Complaint



To determine the problem, turn the ignition switch to accessory and operate the window controls.

1. Operate the "problem" window from both switches.
2. Operate all the other windows also to begin to isolate the problem.

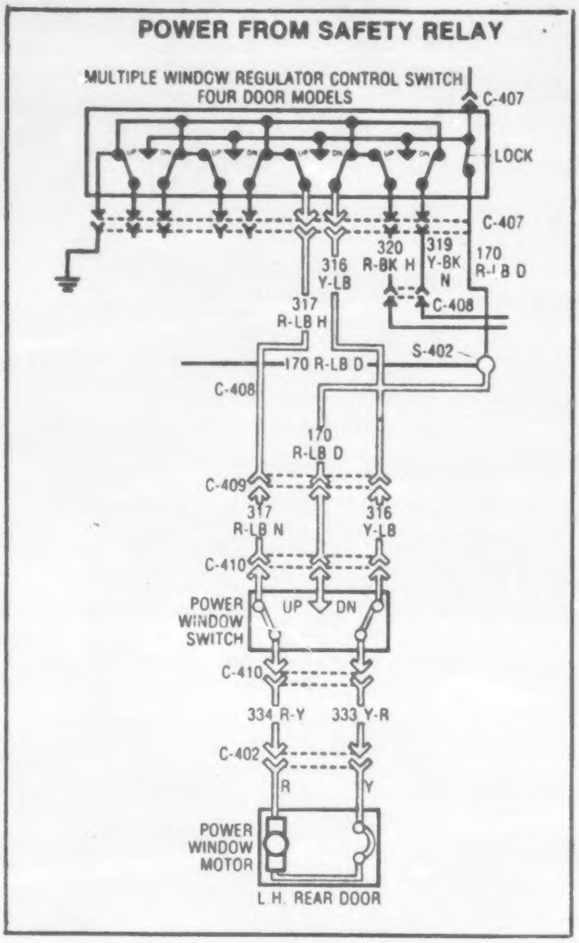
RESULTS. The left rear window cranks up and down slow from either switch. All the other windows are okay from either switch. During left rear window operation, dome light dims noticeably.

Step 2. Define the type of Problem

The three causes of slow motor operation are
1. excessive circuit voltage drop
2. mechanical bind
3. defective motor

From the system operation we can say that the power supply circuit to the master switch is okay since all other windows operate normally. To isolate the problem further we would need to consult a wiring diagram.

Step 3. Isolate the Problem

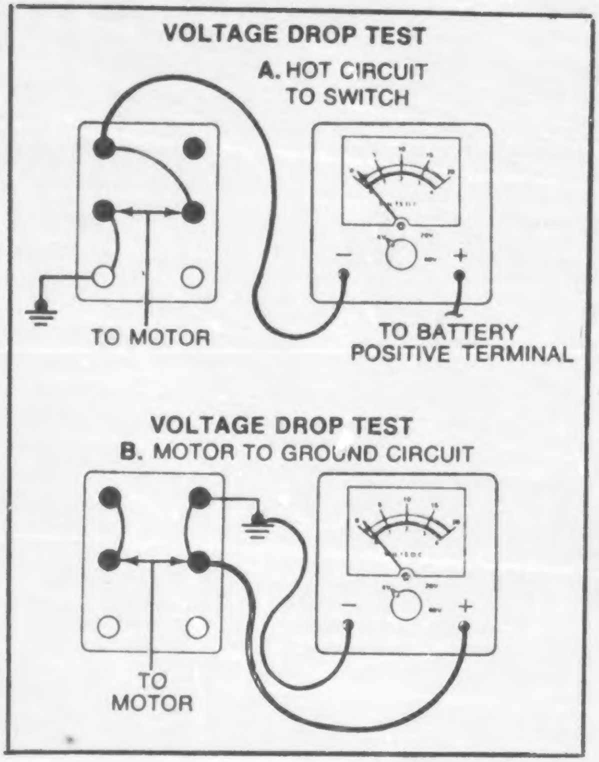

POWER FROM SAFETY RELAY
MULTIPLE WINDOW REGULATOR CONTROL SWITCH
FOUR DOOR MODELS
C-407
LOCK
C-407
320 R-BK H
319 Y-BK N
170 R-LB D
316 Y-LB
C-408
317 R-LB H
S-402
170 R-LB D
C-408
170 R-LB D
C-409
317 R-LB N
316 Y-LB
C-410
POWER WINDOW SWITCH
UP
DN
C-410
334 R-Y
333 Y-R
C-402
R
Y
POWER WINDOW MOTOR
L.H. REAR DOOR

In viewing the diagram for the main switch and left hand rear door circuits, we find that wire 170 is a common point for power to the remaining three windows. Since they operate normally, our problem is beyond splice S-402. Alternate power and ground circuits which only lead to the left rear window are circuits 316, and 317. Further isolation will require testing.

Step 4. Test Systematically

To begin testing, we pop out the rear door switch and install cotter pins for terminals. Remember that the center terminals connect to the motor. We run the motor by making one of them hot from the wire 170 terminal and jumping the other to ground.

We'll start by checking for a high resistance condition.


VOLTAGE DROP TEST
A. HOT CIRCUIT TO SWITCH
TO MOTOR
TO BATTERY POSITIVE TERMINAL
VOLTAGE DROP TEST
B. MOTOR TO GROUND CIRCUIT
TO MOTOR

Test A. Measure the voltage drop from the battery to the hot terminal at the switch.

RESULTS. Less than ½ volt drop.

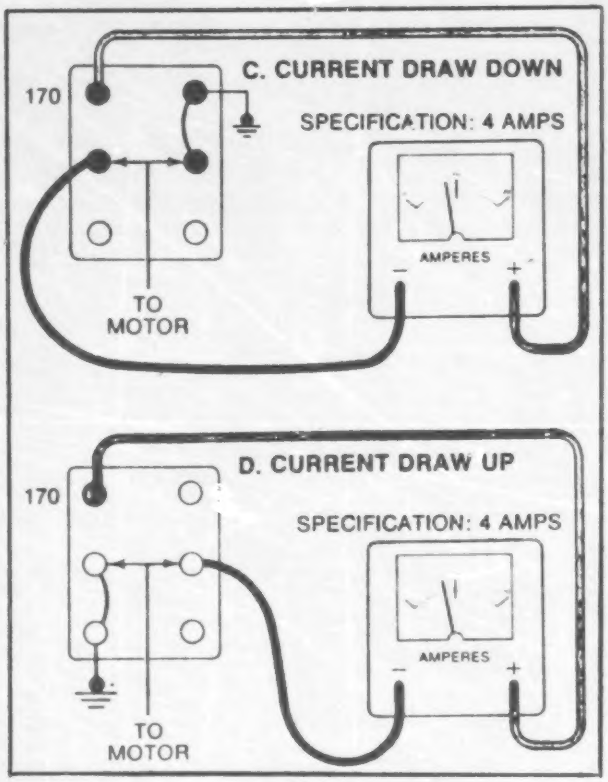
Test B. Measure the voltage drop across the ground circuit (from the door switch through the master switch to ground). Reverse the motor and test the other ground circuit.

RESULTS. The needle barely moves.

CONCLUSION. The only possibility of high resistance left is between the door switch and the motor. Since we'd have to pull the trim panel to get at the motor, we'll make a current draw test where we're at.

Current Draw Tests

To make the current draw tests, we'll again operate the motor from our "terminals" in the door switch connector. Ground one of the motor terminals, and make the other one hot through the ammeter. This places the ammeter is series with the circuit. The motor should draw about 4 amps.



Test C. Measure current draw with the motor cranking the window down.

RESULTS. The motor draws about 8 amps.

Test D. Reverse the motor and measure current draw up.

RESULTS. The motor draws over 8 amps.

CONCLUSION. The circuit is overloaded. Most likely the window mechanism is bound, and is over-working the motor.

(We know now that we're not dealing with a high resistance in series with the motor. That would reduce the current draw.)

Step 5. Verify the cause of the Problem

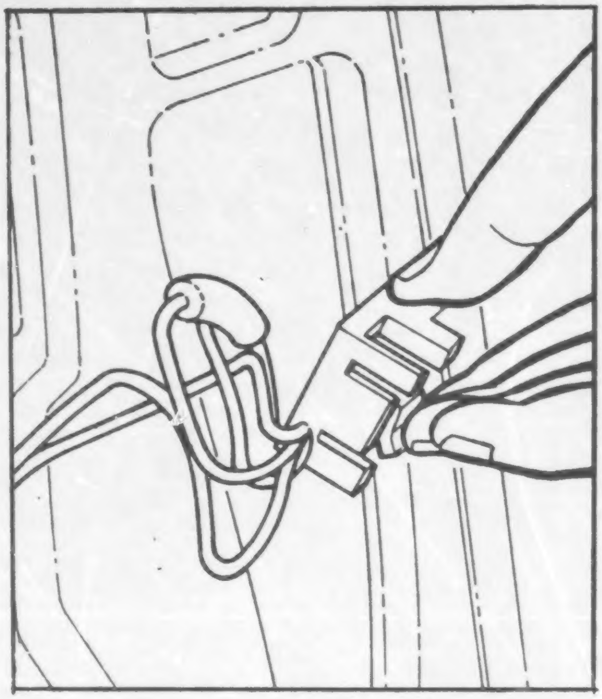
Now we do have to remove the trim panel; but only after verifying that there is an overloaded condition.

With the panel off, we can see readily that the window mechanism is out of adjustment.

Step 6. Repair

To repair the problem, we adjust the window mechanism following the procedures in the Shop Manual. We also inspect the mechanical parts to be sure none are damaged or jammed up.

Step 7. Test the Repair



To test the repair, plug the switch back into the connector and see that the motor opens and closes the window properly. Then reinstall the trim panel to complete the job.

Diagnosis of Slow or Stalled Motor

When our problem is a slow or stalled motor of any kind, there are three most likely causes:

1. High resistance in the circuit. This is diagnosed by voltage drop testing.

2. Mechanical bind or overload. This is diagnosed by measuring current draw.

3. A problem with the motor itslef. If the voltage drop is normal, and the mechanical operation is free, try a new motor. The current draw may be low or high with a defective motor.

Electrical Competencies- Body & Chassis

F-10 Perform Systematic Diagnosis and Testing

Worksheet #1

Instructions:
Obtain a vehicle with an electrical system malfunction. List the seven systematic diagnosis, test, and repair steps below (Part I) and follow then in your repair job. Write a brief explanation of your diagnosis steps in (Part II.)

Part I. List the seven Systematic Diagnosis, Test and Repair Steps.

Part II. Explain your diagnosis steps.

AUTO MECHANICS

Electrical Competencies - Body & Chassis

No. F-11 Identification and Diagnosis of Safety Lighting Circuit

OBJECTIVE: Upon completion of the following material you will be able to locate, identify and diagnosis typical head, tail, parking, license, sidemarker, and back-up light circuits.

EXPLANATION: This will involve locating and tracing down of circuit malfunctions.

MATERIALS NEEDED: Manufacturs wiring diagrams.

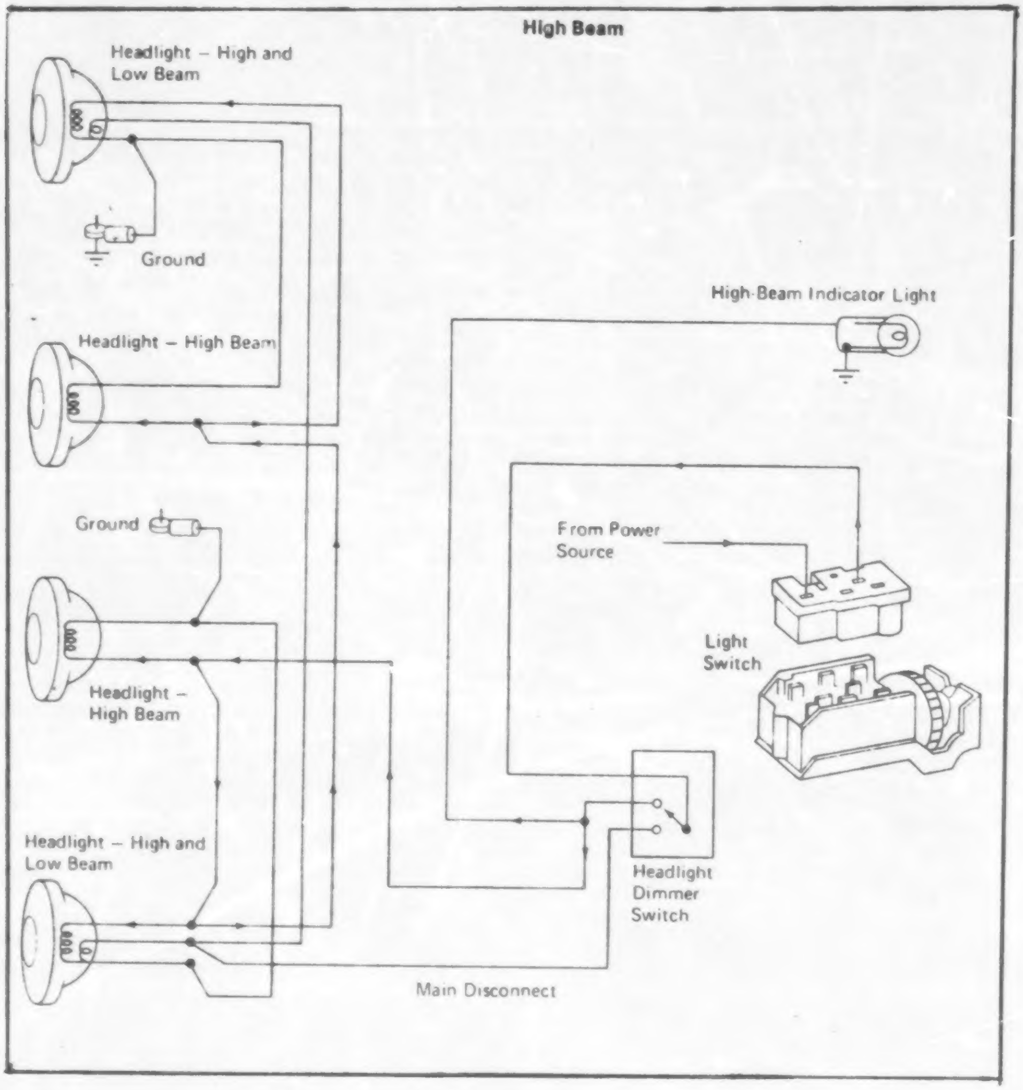
TOOLS NEEDED: Common electrical test equipment.

References	Do
#1. --	1. Study assigned references
#2. Ch. 5, p. 105 Ch.19, p. 398-401 Ch. 6, p. 121 Ch. 4, p. 84,85 #3. p. 690-708, p.442-451, p. 464-473 #4. p. 427-436, p.291-292, p. 462-466 #5. Ch. 32, p. 522-535 #6. Ch. 34 p. 322-333 Ch. 60 p. 598-610 #7. Ch. 23 p. 287-297 #8. Ch. 8 p.178-223	2. Study information sheets 3. Diagnose and repair lighting circuit malfuncations on live vehicle.

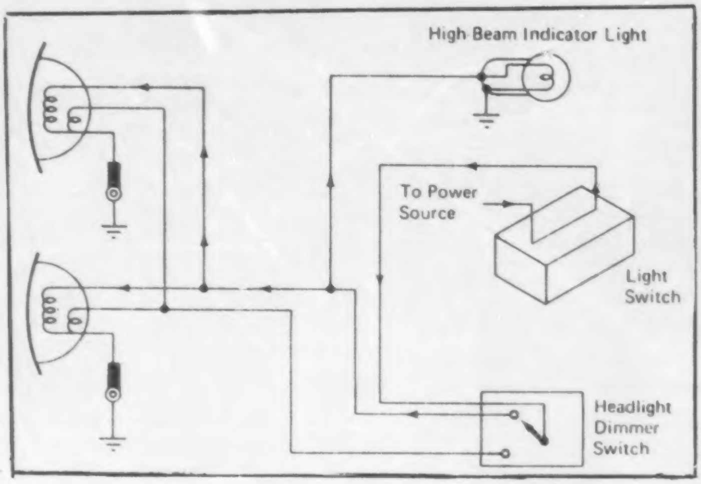
Information Sheet # 1

Headlight Circuit

In a four-lamp dual sealed beam circuit the power comes into the headlight switch and goes through a circuit breaker inside the headlight switch to a dimmer switch. The dimmer switch can be in either the high beam or a low beam position. If the high beam is selected, the current will travel to the inboard and outboard lights and also to the high-beam indicator on the dashboard. The indicator light informs the driver that the high beams are on. With the dimmer switch on the low-beam selection, the circuit power feeds the low-beam filaments on the outboard lights only.


High Beam
Headlight – High and Low Beam
Ground
Headlight – High Beam
High-Beam Indicator Light
From Power Source
Ground
Light Switch
Headlight – High Beam
Headlight – High and Low Beam
Headlight Dimmer Switch
Main Disconnect

A two-lamp sealed-beam circuit is shown; it works in a manner similar to the four-lamp circuit just described.

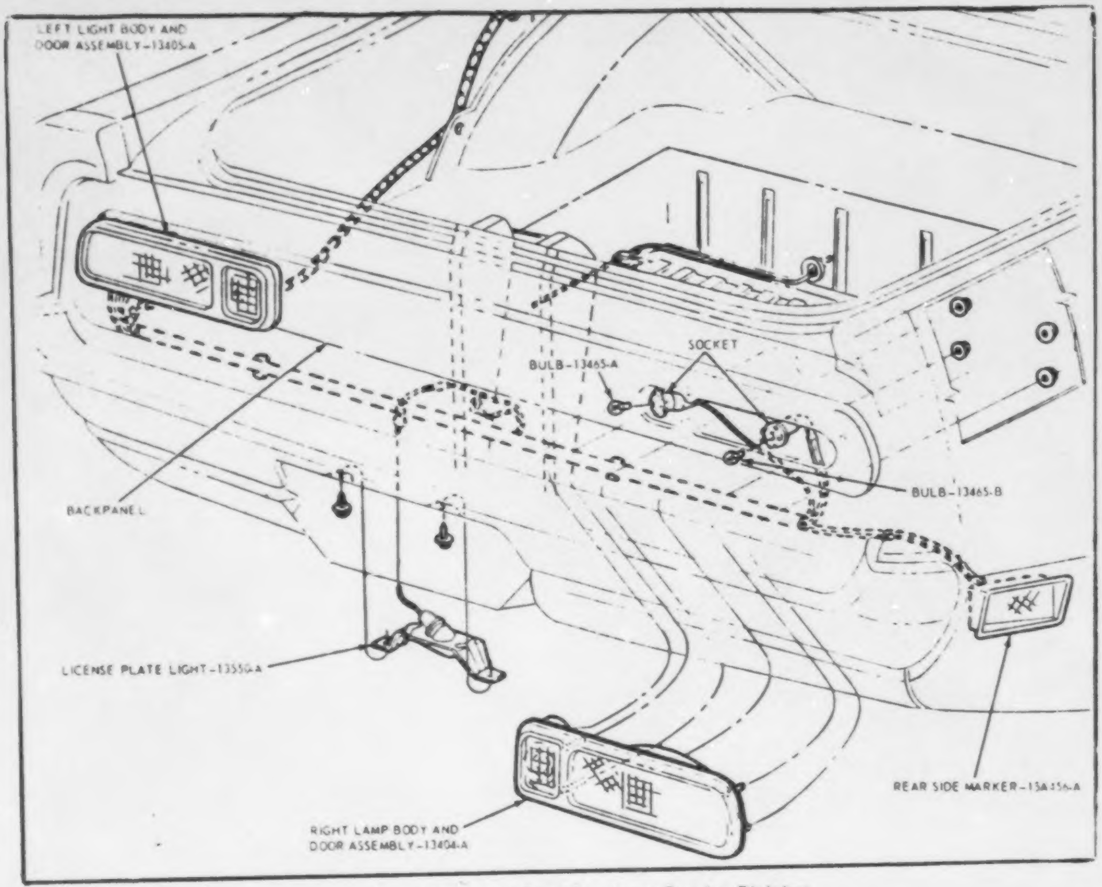


Courtesy of Ford Customer Service Division.

HEADLAMP DIAGNOSIS

Condition	Possible Cause	Correction
One headlamp inoperative or intermittent	1. Loose connection	1. Secure connections to sealed beam including ground. (Black Wire)
	2. Sealed Beam Malfunction	1. Replace sealed beam
One or more headlights are dim.	1. Open ground connection at headlight	1. Repair black wire connection between sealed beam and body ground.
	2. Black ground wire mislocated in headlight connector (type 2 sealed beam)	1. Relocate black wire in connector
One or more headlights short life	1. Voltage regulator malfunction	1. Replace voltage regulator
All headlights inoperative or intermittent	1. Loose connection	1. Check and secure connections at dimmer switch and light switch.
	2. Dimmer switch malfunction	1. Check voltage at dimmer switch with test lamp. If test lamp bulb lights only at light blue wire terminal, replace dimmer switch.

Condition	Possible Cause	Correction
	3. Open wiring - light switch to dimmer switch	1. Check light blue wire with test lamp. If bulb lights at light switch light blue wire terminal but not at dimmer switch, repair open wire.
	4. Open wiring - light to battery	1. Check red wire terminal at light switch with test lamp. If lamp does not light, repair open red wire circuit to battery. (possible open fusible link)
	5. Shorted ground circuit	1. If, after a few minutes operation, headlights flicker "ON" and "OFF" and or a thumping noise can be heard from the light switch (circuit breaker opening and closing), repair short to ground in circuit between light switch and headlights. After repairing short, check for headlight flickering after one minute operation. If flickering occurs, the circuit breaker has been damaged and light switch must be replaced.
	6. Light switch malfunction	1. Check red and white wire terminals at light switch with test lamp. If bulb lights at read wire terminal but not at light blue terminal, replace light switch.
Upper or lower beam will not light or intermittent	1. Dimmer switch malfunction or open connection	1. Check dimmer switch terminals with test lamp. If bulb lights at light blue or tan wire terminals, repair open wiring between dimmer switch and headlights. If bulb will not light at one of these terminals, replace dimmer switch.
	2. Short circuit to ground	1. Follow diagnosis above (All headlights inoperative or intermittent)


LEFT LIGHT BODY AND
DOOR ASSEMBLY-13405-A
SOCKET
BULB-13465-A
BULB-13465-B
BACKPANEL
LICENSE PLATE LIGHT-13550-A
REAR SIDE MARKER-13A356-A
RIGHT LAMP BODY AND
DOOR ASSEMBLY-13404-A

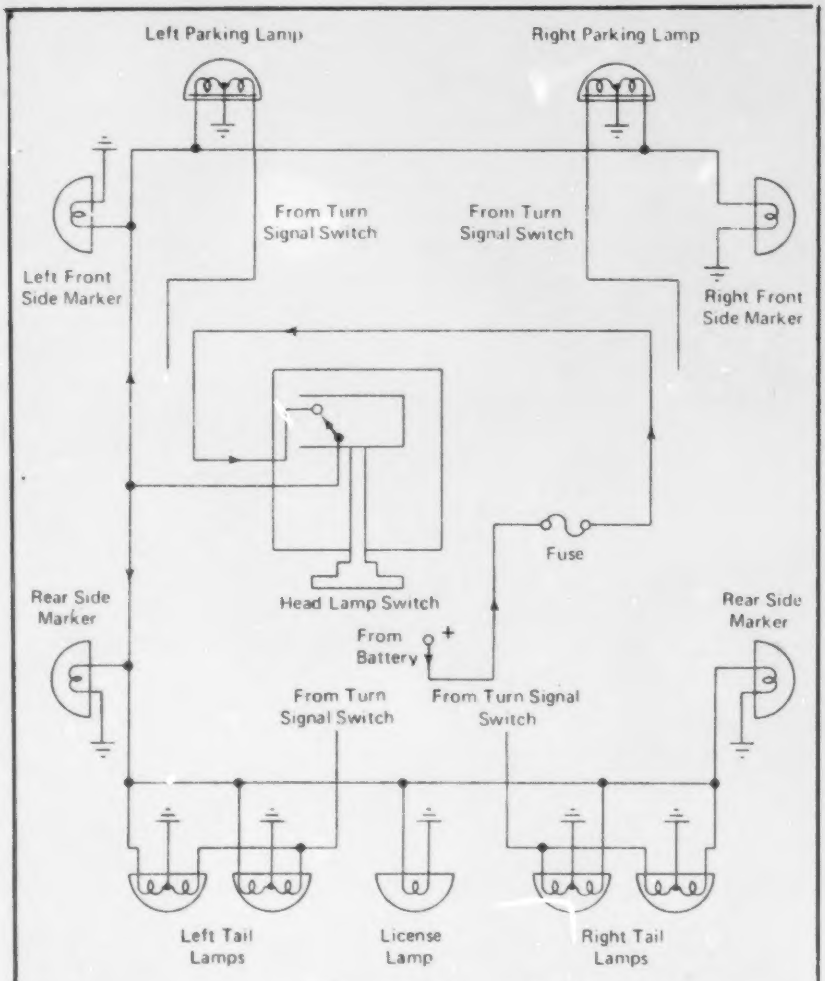
Courtesy of the Ford Customer Service Division.

TAIL, PARK AND LICENSE LAMP DIAGNOSIS

Condition	Possible Cause	Correction
One side inoperative	1. Bulb burnt out	1. Replace bulb
	2. Open ground connection at bulb socket or ground wire terminal	1. Jumper bulb base socket connection to ground. If lamp lights, repair open ground circuit.
Both sides inoperative	1. Tail lamp fuse blown	1. Replace fuse. If new fuse blows, repair short to ground in brown wire circuit between fuse panel through light switch to lamps.
	2. Loose connection	1. Secure connector at light switch.
	3. Open wiring	1. Using test light, check circuit on both sides of fuse. If lamp does not light on either side, repair open circuit between fuse panel and battery. (possible open fusible link). If test lamp lights at light switch brown wire terminal, repair open wiring between light switch and lamps.

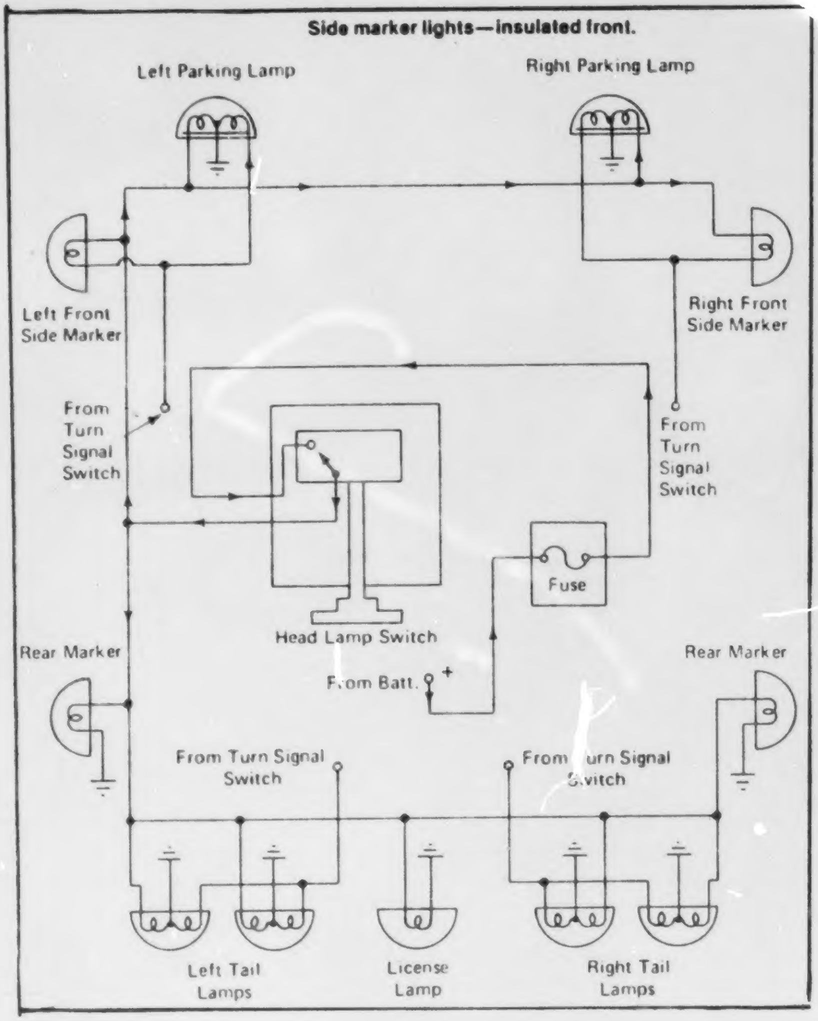
SIDE MARKER LIGHTS

For added nighttime driving safety, exterior automobile lighting now includes side marker lights. An amber-lensed light is used on the left and right sides of the vehicle front and a red-lensed light on the left and right sides of the vehicle rear. These lights glow continuously when the park lights or headlights are on. Typical wiring circuits are shown note that the front side marker lights either have a direct ground to the body sheet metal or are connected across the turn signal and park light circuits.


Left Parking Lamp
Right Parking Lamp
From Turn Signal Switch
From Turn Signal Switch
Left Front Side Marker
Right Front Side Marker
Fuse
Rear Side Marker
Head Lamp Switch
Rear Side Marker
From Battery
+
From Turn Signal Switch
From Turn Signal Switch
Left Tail Lamps
License Lamp
Right Tail Lamps

Side marker lights—grounded front.

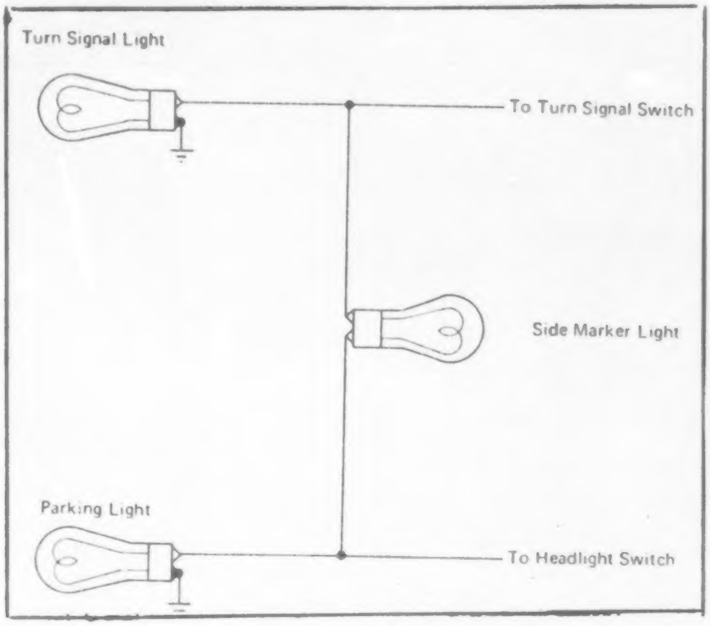
In the next circuit the front side marker lights will flash when the turn signal is activated. One side of each marker light is connected to the parking lights circuit, the other to the turn signal circuit.



Side marker lights—insulated front.

Left Parking Lamp
Right Parking Lamp
Left Front Side Marker
Right Front Side Marker
From Turn Signal Switch
From Turn Signal Switch
Fuse
Head Lamp Switch
Rear Marker
Rear Marker
From Batt. +
From Turn Signal Switch
From Turn Signal Switch
Left Tail Lamps
License Lamp
Right Tail Lamps

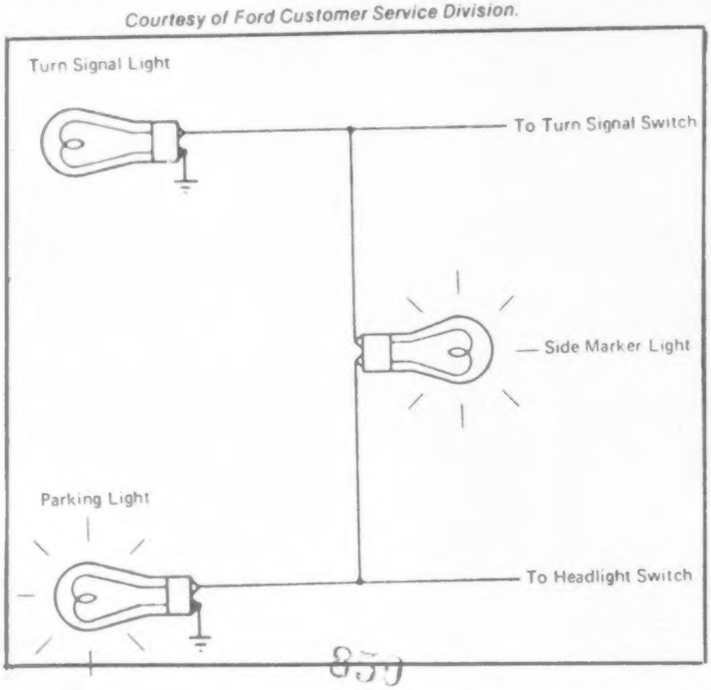
When power is applied to the parking light circuit, with the turn signal switch off, the parking lights and the side marker lights shine.


Turn Signal Light
To Turn Signal Switch
Side Marker Light
Parking Light
To Headlight Switch

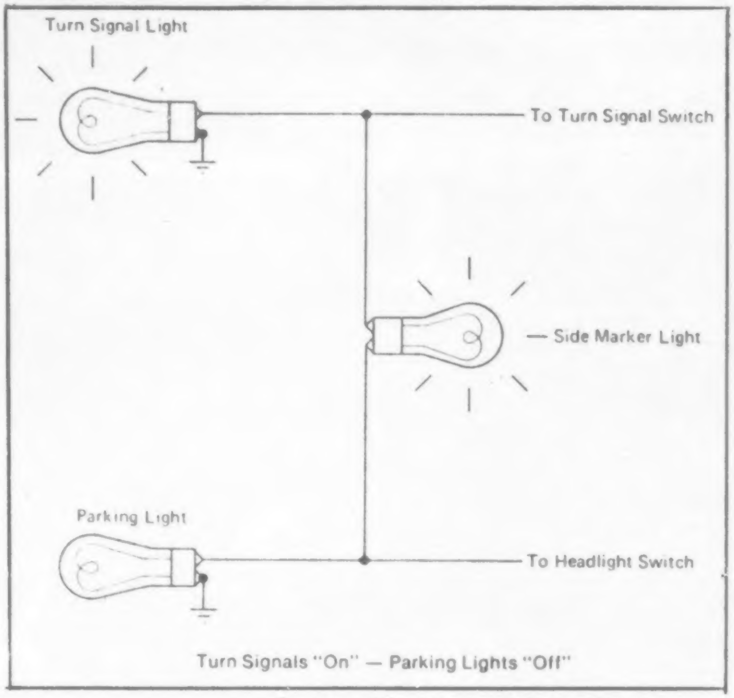
Courtesy of Ford Customer Service Division.

(The side marker lights are grounded through the turn signal bulb filaments.) The current passing through the side marker lights is not enough to light the turn signal light.

Courtesy of Ford Customer Service Division.


Turn Signal Light
To Turn Signal Switch
Side Marker Light
Parking Light
To Headlight Switch

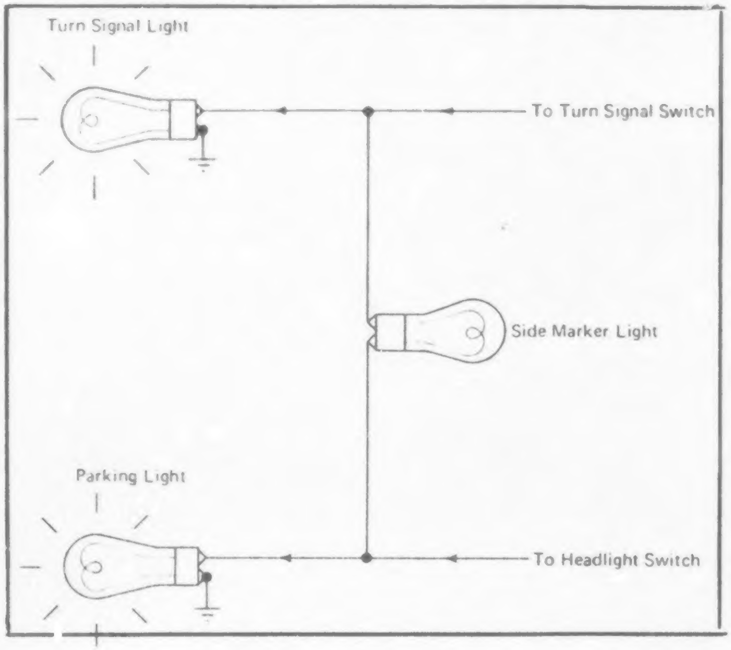
When the turn signal lights are on with the parking lights off, the side market lights are grounded through the parking light bulb filaments. The turn signal lights and the side marker lights flash simultaneously.


Turn Signal Light
To Turn Signal Switch
Side Marker Light
Parking Light
To Headlight Switch
Turn Signals "On" — Parking Lights "Off"

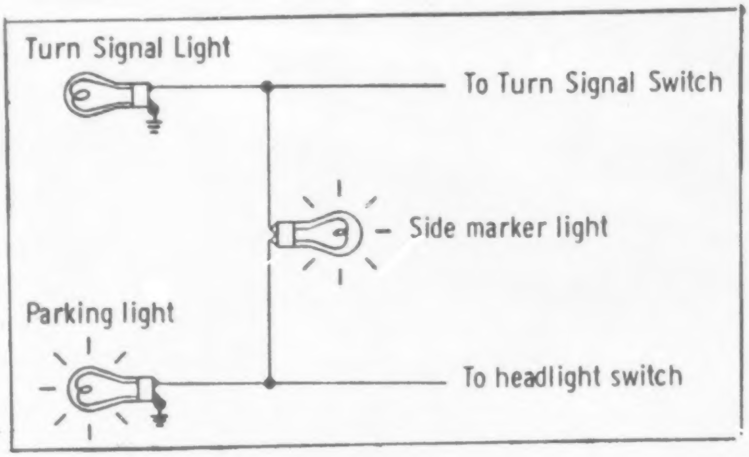
Courtesy of Ford Customer Service Division.

If the parking lights are on when the turn signal light comes on, equal power is applied to both sides of the marker lights. The side marker lights will not shine.

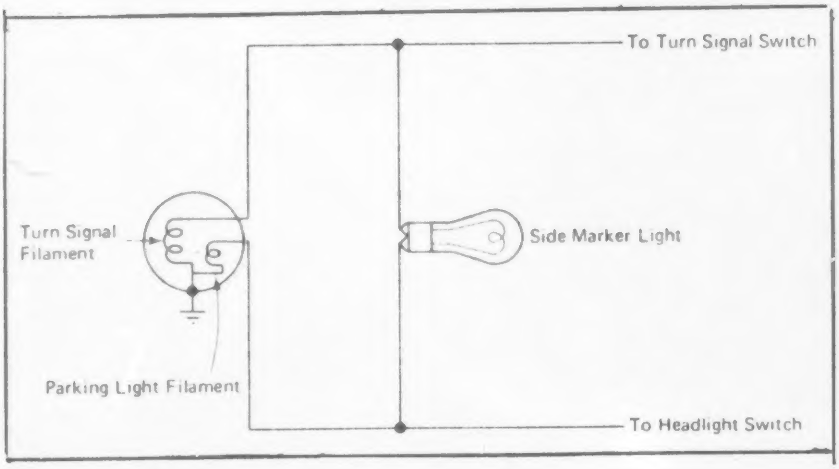
Courtesy of Ford Customer Service Division.


Turn Signal Light
To Turn Signal Switch
Side Marker Light
Parking Light
To Headlight Switch

But when the trun signal flasher shuts off power to the turn signal light, with the parking lights on, the side marker lights shine. In other words, it the parking lights are on when the turn signal switch is actuated, the side marker lights and the turn lights flash alternately.


Turn Signal Light
To Turn Signal Switch
Side marker light
Parking light
To headlight switch

Finally this circuit shows the turn signal and park light filaments assembled into one-dual-filament light bulb. (1157 or 1034).


To Turn Signal Switch
Turn Signal Filament
Side Marker Light
Parking Light Filament
To Headlight Switch

SIDE MARKER LAMP DIAGNOSIS

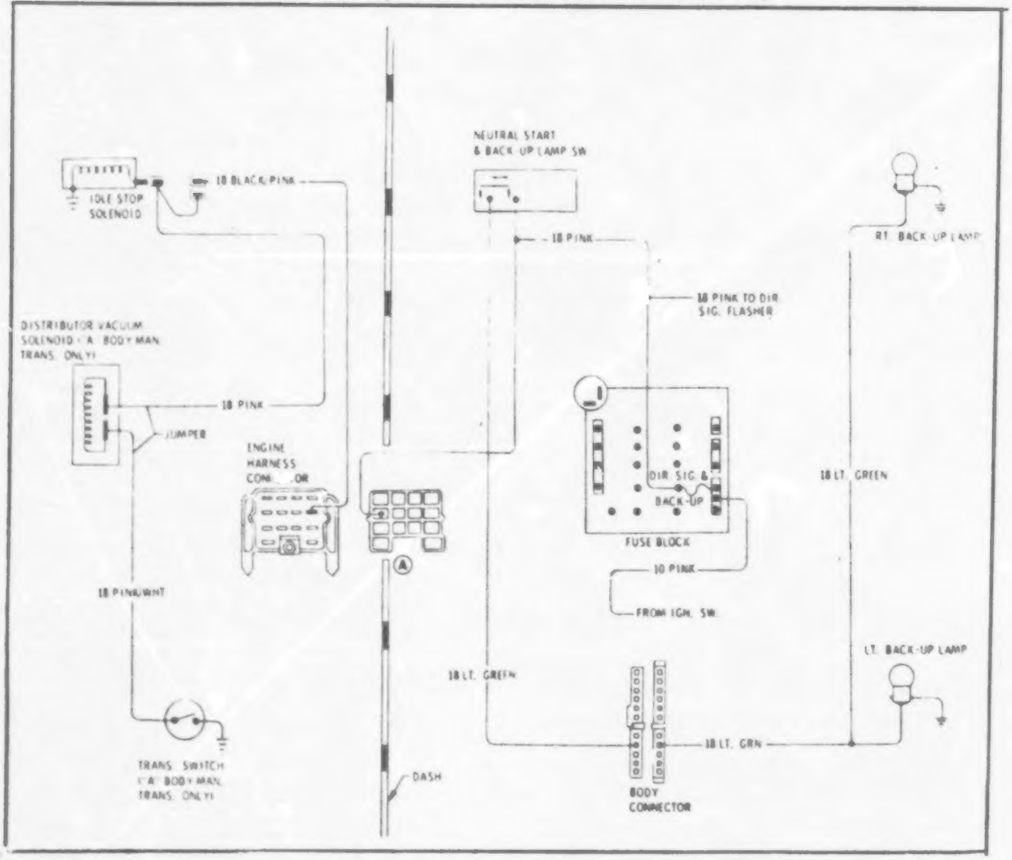
Condition	Possible Cause	Correction
One lamp inoperative	1. Turn signal bulb burnt out (Front lamp)	1. Switch turn signals on. If signal bulb does not light, replace bulb. (Bulb filament provides ground path for marker lamp bulb through the light blue or dark blue/white strip wires).
	2. Side marker bulb burnt out	1. Replace bulb.
	3. Loose connection or open in wiring	1. Using test lamp, check brown wire terminal at bulb socket. If test lamp lights, repair open ground circuit. If lamp does not light, repair open brown wire circuit.
Front or rear lamps inoperative	1. Loose connection or open ground connection	1. If associated tail or park lamps do not operate, secure all connectors in brown wire circuit. If park and turn lamps operate, repair open ground connections.
	2. Multiple bulbs burnt out	1. Replace burnt out bulbs.
All lamps inoperative	1. Blown fuse	1. If park and tail lamps do not operate, replace blown fuse. If new fuse blows, check for short to ground between fuse panel and lamps.
	2. Loose connection	1. Secure connector to light switch.
	3. Open in wiring	1. Check tail light fuse with test lamp. If test lamp lights, repair open wiring between fuse and light switch. If not, repair open wiring between fuse and battery. (Possible open fusible link).
	4. Light switch malfunction	1. Check light switch with test lamp. If test lamp lights at terminal No. 5 but not at terminal No. 4, replace light switch.

BACKUP LIGHTS

Backup lights illuminate the road to the rear of the vehicle and provide a warning signal to pedestrians and other drivers when the vehicle is backing up or about to back up.

In the backup light circuit illustrated the power from the fuse block is continued to the neutral safety switch. When the driver puts the car into reverse, this closes the backup light switch contacts within the neutral safety switch, and completes circuit to the backup lights.

Backup light switches are usually found under the dash on the steering column or on the left side of the transmission. The ignition key must be on for circuit power.


NEUTRAL START
& BACK-UP LAMP SW
IDLE STOP
SOLENOID
18 BLACK/PINK
18 PINK
18 PINK TO DIR.
SIG. FLASHER
RT. BACK-UP LAMP
DISTRIBUTOR VACUUM
SOLENOID ("A" BODY MAN.
TRANS. ONLY)
18 PINK
JUMPER
ENGINE
HARNESS
CONNECTOR
A
DIR. SIG &
BACK-UP
FUSE BLOCK
18 LT. GREEN
10 PINK
FROM IGN. SW.
18 PINK/WHT
18 LT. GREEN
LT. BACK-UP LAMP
18 LT. GRN
TRANS. SWITCH
("A" BODY MAN.
TRANS. ONLY)
DASH
BODY
CONNECTOR

Courtesy of Buick Division of General Motors Corp.

Condition	Possible Cause	Correction
BACK-UP LAMP		
One lamp inoperative or intermittent	1. Loose or burnt out bulb	1. Secure or replace bulb.
	2. Loose connection	1. Tighten connectors.
	3. Open ground connections	1. Repair bulb ground circuit.
Both lamps inoperative or intermittent.	1. Neutral start switch misadjusted (Open when shift lever is in reverse position)	1. Readjust neutral start switch.
	2. Loose connection or open circuit	1. Secure all connectors. If OK, check continuity of circuit from fuse to lamps with test lamp. If lamp does not light on either side of fuse, correct open circuit from battery to fuse.
	3. Blown fuse	1. Replace fuse. If new fuse blows, repair short to ground in circuit from fuse through neutral start switch to back-up lamps.
	4. Defective neutral start switch	1. With ignition on, check switch terminals in back-up position with test lamp. If lamp lights at pink wire terminal but not at light green wire terminal, replace neutral start switch.
	5. Defective ignition switch	1. If test lamp lights at ignition switch battery terminal but not at output terminal, replace ignition switch.
Lamp will not turn off	1. Neutral start switch misadjusted (closed when shift lever is not in reverse position)	1. Readjust neutral start switch

AUTO MECHANICS

Electrical Competencies- Body & Chassis

No. F-12 Identify and Diagnosis Typical Turn Signal, Hazard, Warning, Stop light, and cornering light circuits

OBJECTIVE:

Upon completion of the following material you will be able to locate, identify, and diagnose any malfunctions in teh turn, hazard, stop and cornering lights.

EXPLANATION:

This will involve a visual diagnosis of malfunctioning lights and identifying the cause.

MATERIALS NEEDED:

Manufacturers wiring diagram

TOOLS NEEDED:

Common electrical test equipment.

References	Do
#1. --	#1. Study assigned references.
#2. Ch. 5, p. 195 Ch. 19, p. 398-401 Ch. 6, p. 121 Ch. 4, p. 84-85	#2. Study Information Sheet.
#3. p. 690-708 p. 442-451 p. 464-473	#3. Diagnose and repair lighting circuit malfunctions on live vehicle.
#4. p. 427-436 p. 291-292 p. 462-466	
#5. Ch. 32, p. 522-535	
#6. Ch. 34, p. 322-333 Ch. 60, p 598-610	
#7. Ch. 23, p. 287-297	
#8. Ch. 8, p. 178-223	

Electrical Comptetncies- Body & Chassis

No. F12 Identify and Diagnose Typical Turn Signal,
Hazard Warning, Stop Light, and
Cornering Light Circuits

Information Sheet #1

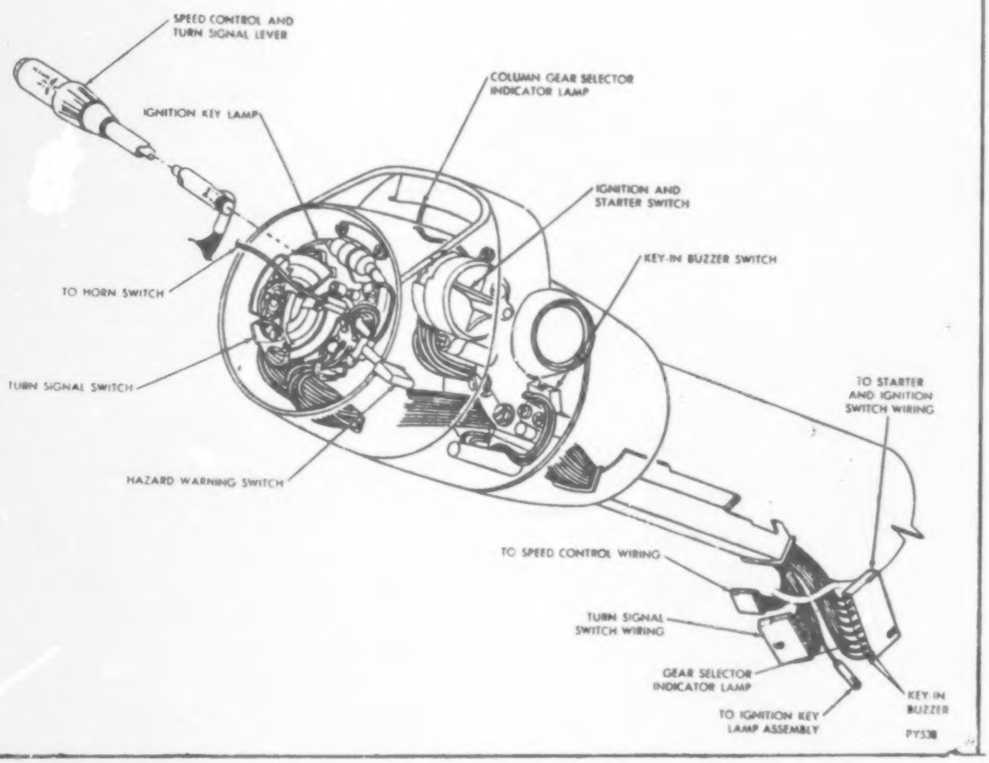
Turn Signals

The turn signal circuit consists of the switch and flasher, two signal indicator bulbs on the instrument panel, the stoplight filaments in the rear lighting, and the turn signal filaments in the parking light bulbs and front side marker lights.

The circuit is controlled by the turn signal switch, which is mounted in a housing at the upper end of the steering column just below the steering wheel. When the turn signal switch is operated to indicate a turn or a lane change, the front and rear signal lights and the front side marker lights flash on and off on the left or right side of the car, as chosen by the driver. A turn indicator bulb on the instrument panel also flashes with the turn signal lights.

After a turn is completed, the return of the steering wheel to a straight-ahead position cancels the signal circuit. On slight turns such as those used in a lane change, the return of the steering wheel to a straight-ahead position will not cancel the circuit. This is normal and the turn signal switch must be returned to its neutral position by the driver.

Courtesy of The Chrysler Corporation.

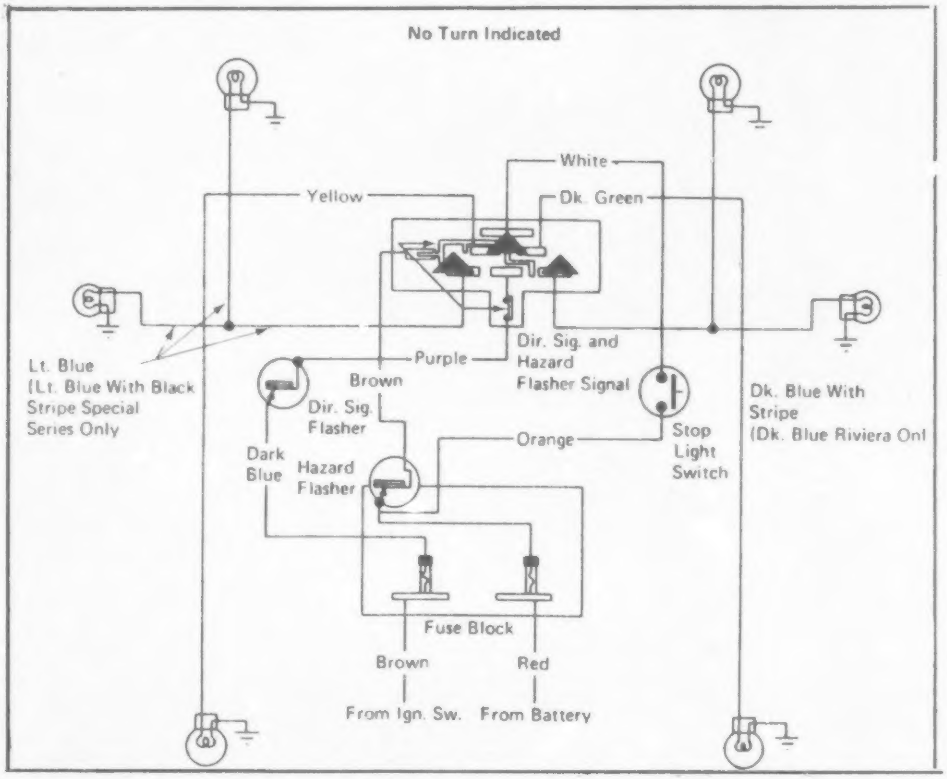

SPEED CONTROL AND TURN SIGNAL LEVER
COLUMN GEAR SELECTOR INDICATOR LAMP
IGNITION KEY LAMP
IGNITION AND STARTER SWITCH
KEY-IN BUZZER SWITCH
TO HORN SWITCH
TURN SIGNAL SWITCH
TO STARTER AND IGNITION SWITCH WIRING
HAZARD WARNING SWITCH
TO SPEED CONTROL WIRING
TURN SIGNAL SWITCH WIRING
GEAR SELECTOR INDICATOR LAMP
KEY-IN BUZZER
TO IGNITION KEY LAMP ASSEMBLY
PY538

The turn signal circuit operation will be shown in the neutral, left turn, and right turn positions. A study of the turn signal switch shows that the switch receives power from two different sources- the stop light circuit and the flasher circuit.

Neutral

In the neutral position, battery voltage from the ignition switch is available to the fuse block, and through the fuse, to the turn signal flasher. Voltage continues through the flasher to the center terminal of the turn signal switch. The voltage is always at the center terminal waiting for a turn to be selected to complete the circuit.

When the stop light switch is closed the circuit is completed through the turn signal switch to the high-current filaments in the taillight bulbs. During left and right turns the stop lights and turn signal lights will share these same filaments.


No Turn Indicated
White
Yellow
Dk. Green
Lt. Blue
(Lt. Blue With Black
Stripe Special
Series Only
Purple
Brown
Dir. Sig. and
Hazard
Flasher Signal
Dir. Sig.
Flasher
Dk. Blue With
Stripe
(Dk. Blue Riviera Onl
Orange
Stop
Light
Switch
Dark
Blue
Hazard
Flasher
Fuse Block
Brown
Red
From Ign. Sw.
From Battery

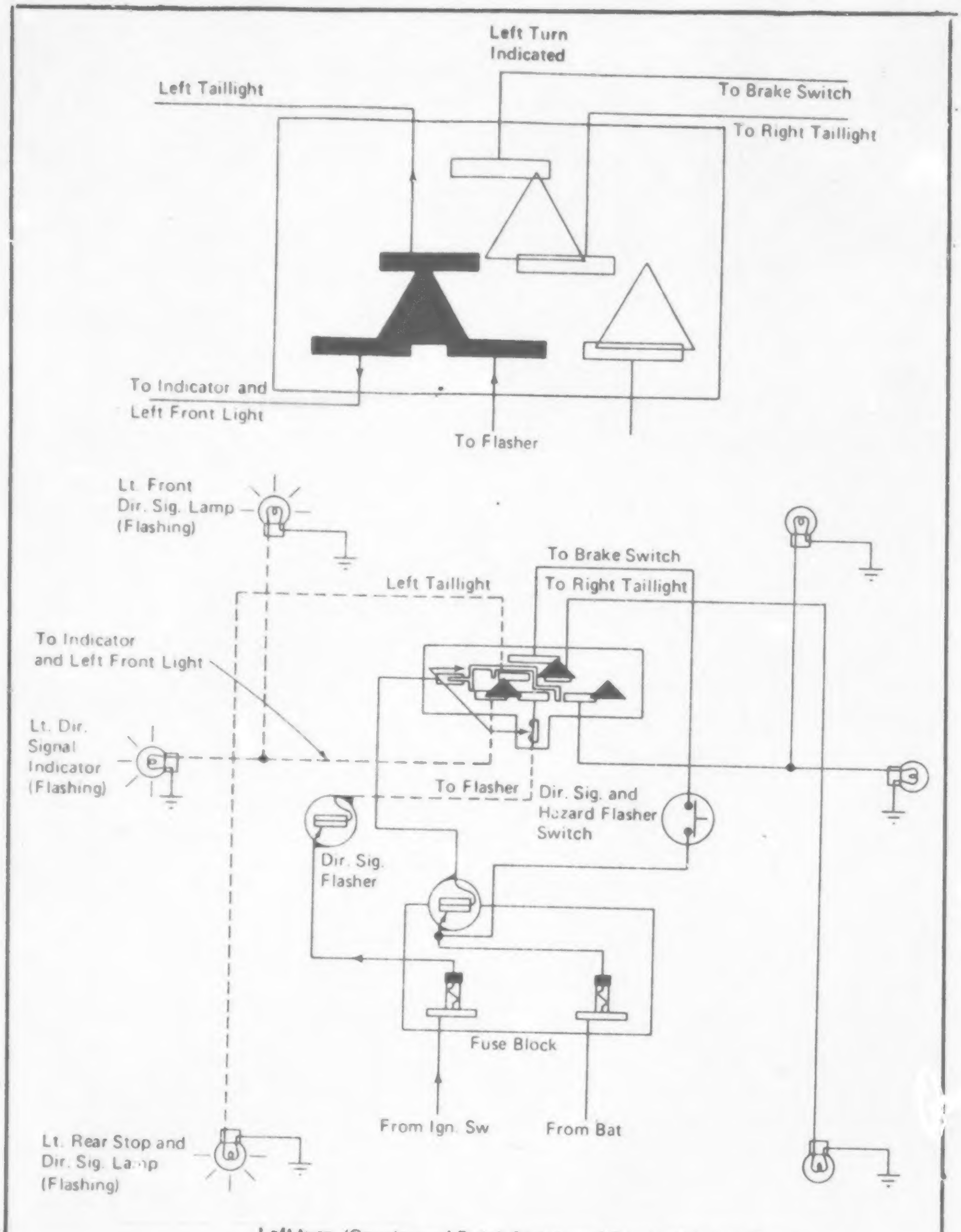
Neutral. *(Courtesy of Buick Division of General Motors Corp.)*

Left Turn

When a left turn is signalled, the turn signal switch makes contact with the center terminal, the left rear ligh terminal, and the left front terminal to complete the circuit. The flasher is now sensitive to the current flow and will heat up and break the circuit. When the flasher cools, contact will be made again and the cycle repeated.

No. F 12 Identify and Diagnose Typical Turn Signal,
Hazard, Warning, Stop Light, and
Cornering Light Circuits

During a left turn, the turn signal switch cuts off the stop light circuit from the left rear lights, and only the right side will provide a steady glow.

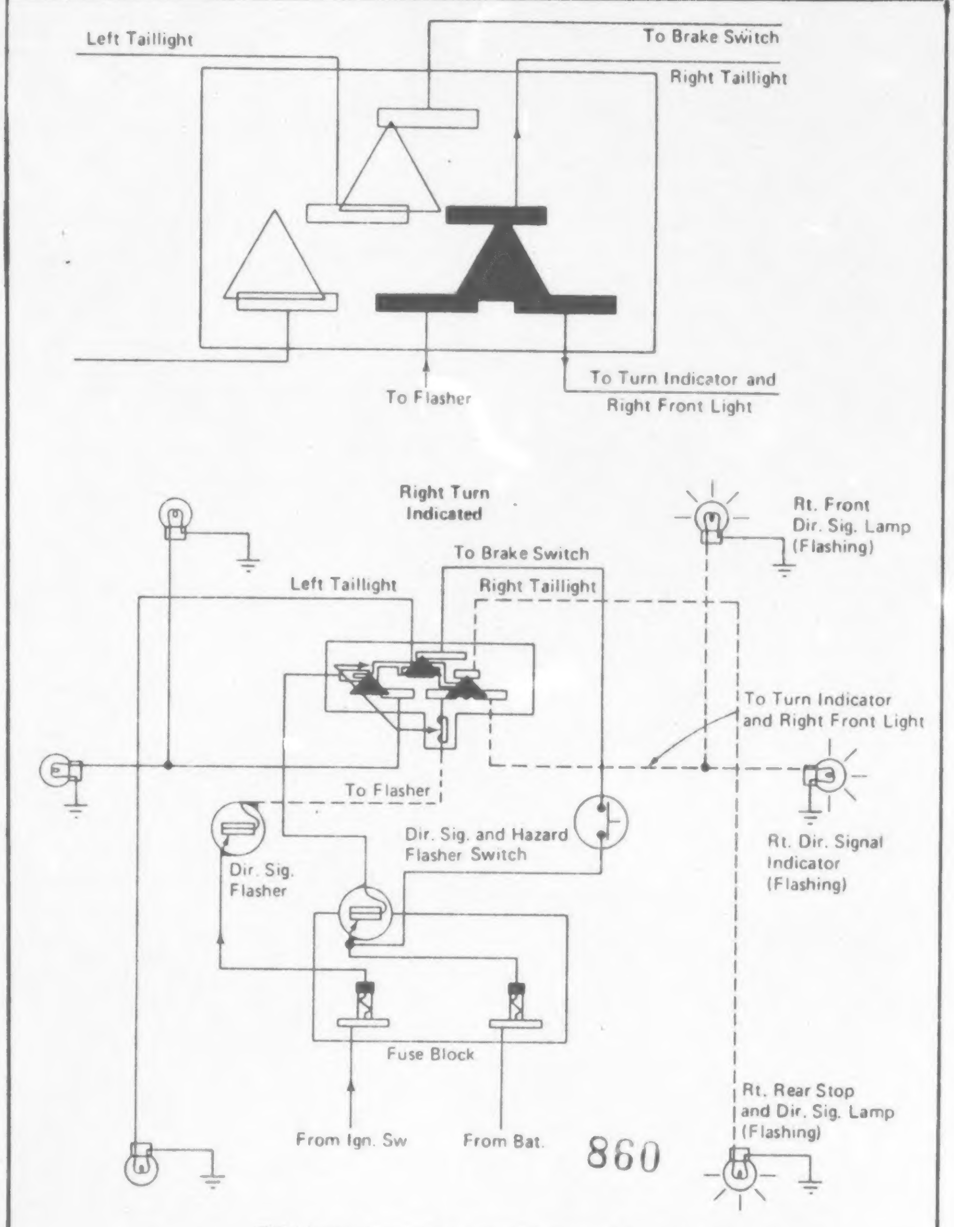

Left Turn
Indicated
Left Taillight
To Brake Switch
To Right Taillight
To Indicator and
Left Front Light
To Flasher
Lt. Front
Dir. Sig. Lamp
(Flashing)
To Brake Switch
To Right Taillight
Left Taillight
To Indicator
and Left Front Light
Lt. Dir.
Signal
Indicator
(Flashing)
To Flasher
Dir. Sig. and
Hazard Flasher
Switch
Dir. Sig.
Flasher
Fuse Block
From Ign. Sw
From Bat
Lt. Rear Stop and
Dir. Sig. Lamp
(Flashing)

Left turn. *(Courtesy of Buick Division of General Motors Corp.)*

Right Turn

When a right turn is signalled, the turn signal switch makes contact with the center terminal, the right rear light terminal, and right front terminal to complete the circuit. The flasher is now sensitive to the current flow and will heat up and break the circuit. When the flasher cools, contact will be made again and the cycle repeated.

During a right turn, the turn signal switch cuts off the stop light circuit from the right lights, and only the left side will provide a steady glow.


Left Taillight
To Brake Switch
Right Taillight
To Flasher
To Turn Indicator and
Right Front Light
Right Turn
Indicated
Rt. Front
Dir. Sig. Lamp
(Flashing)
To Brake Switch
Left Taillight
Right Taillight
To Turn Indicator
and Right Front Light
To Flasher
Dir. Sig. and Hazard
Flasher Switch
Dir. Sig.
Flasher
Rt. Dir. Signal
Indicator
(Flashing)
Fuse Block
From Ign. Sw
From Bat.
Rt. Rear Stop
and Dir. Sig. Lamp
(Flashing)
860

Right turn. *(Courtesy of Buick Division of General Motors Corp.)*

TURN SIGNAL

Condition	Possible Cause	Correction
Turn signals inoperative one side	1. Bulb(s) burnt out (Flasher cannot be heard)	1. Turn hazard warning system on. If one or more bulbs are inoperative replace necessary bulbs.
	2. Open wiring or ground connection	1. Turn hazard warning system on. If one or more bulbs are inoperative, use test lamp and check circuit at lamp socket. If test lamp lights, repair open ground connection. If not, repair open wiring between bulb socket and turn signal switch.
	3. Improper bulb or defective turn signal switch.	1. Turn hazard warning system on. If all front and rear lamps operate, check for improper bulb (1034 instead of 1157). If bulbs are OK, replace defective turn signal switch.
	4. Short to ground. (Flasher can be heard, no bulbs operate)	1. Locate and repair short to ground by disconnecting front and rear circuits separately.
Turn signals inoperative	1. Blown turn signal fuse	1. Turn hazard warning system on. If all lamps operate, replace blown fuse. If new fuse blows, repair short to ground between fuse and lamps.
	2. Defective flasher (Located behind instrument panel near steering column)	1. If turn signal fuse is OK and hazard warning system will operate lamps, replace defective turn signal flasher.
	3. Loose connection	1. Secure steering column connector. If necessary, check purple wire terminals in connector with test lamp. If test lamp lights only on one side of connector, clean or tighten connector contacts.

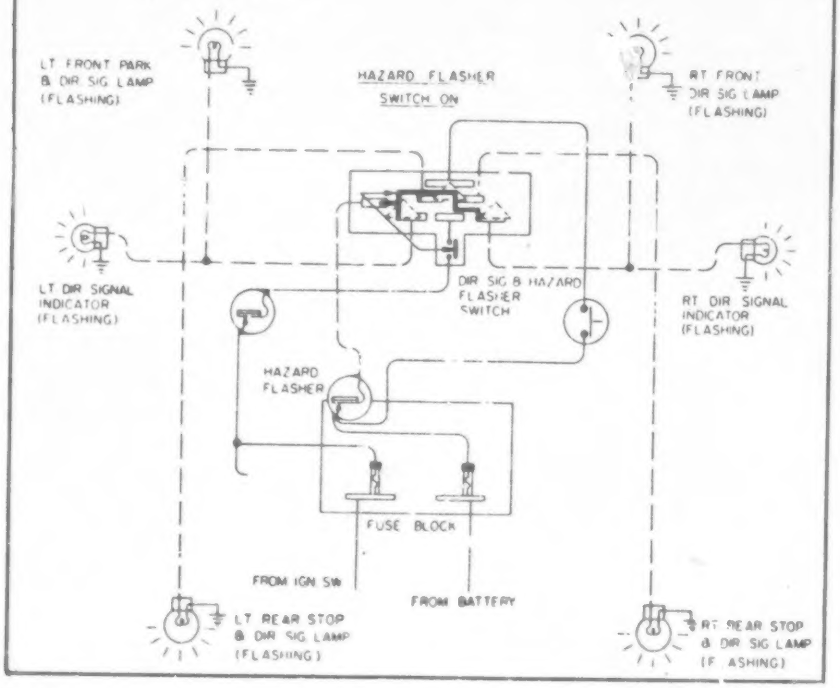
Hazard Warning Lights

All cars manufactured in production year 1967 or later are equipped with a system of warning lights to signal any unusual or dangerous condition, such as a disabled car stopped by the side of the road, or some other emergency situation. The hazard warning feature, when turned on, causes all turn signal lights plus the indicator lights to flash simultaneously.

This system is integrated into the turn signal circuit and makes use of the regular turn signal wiring and lights, but has a separate power supply, flasher unit, and on-off switch. The switch is usually located just below the steering wheel on the right side of the steering column, or it may be found on the instrument panel.

A typical hazard warning system is shown in its power "on" position. The switch controls the flow of power in the circuit as it parallels the left and right sides of the turn signals when closed. Also note that the circuit is energized directly from the battery through the fuse block and can operate with the ignition switch either on or off.

Hazard warning system—power "on." *(Courtesy Buick Division of General Motors Corp.)*


LT FRONT PARK
& DIR SIG LAMP
(FLASHING)
HAZARD FLASHER
SWITCH ON
RT FRONT
DIR SIG LAMP
(FLASHING)
LT DIR SIGNAL
INDICATOR
(FLASHING)
DIR SIG & HAZARD
FLASHER
SWITCH
RT DIR SIGNAL
INDICATOR
(FLASHING)
HAZARD
FLASHER
FUSE BLOCK
FROM IGN SW
FROM BATTERY
LT REAR STOP
& DIR SIG LAMP
(FLASHING)
RT REAR STOP
& DIR SIG LAMP
(FLASHING)

HAZARD WARNING LAMP

Hazard warning lamps inoperative	1. Blown stop-hazard fuse	1. Switch turn signals on. If lamps operate, replace stop-hazard fuse if blown. If new fuse blows, repair short to ground. (Could be in stop light circuit).
	2. Defective hazard warning flasher. (Located on fuse panel).	1. If stop-hazard fuse is OK, switch turn signals on. If lamps operate, replace defective hazard flasher.
	3. Open in wiring or defective turn signal switch.	1. Using test lamp, check brown wire in turn signal steering column connector. If lamp does not light on either side of connector, repair open circuit between flasher and connector. If lamp lights only on feed side of connector, clean connector contacts. If lamp lights on both sides of connector, replace defective turn signal switch assembly.

Turn Signal Flasher Units

The flasher is a very simple thermally actuated circuit breaker. Its normal flash rate varies between 60 and 120 flashes per minute. Should a front or rear bulb burn out, the reduced current in the circuit will cause the remaining signal on the side of the car to glow steadily.

The flasher is mounted in a variety of locations; fuse block, safety panel above the glove box, taped on the wiring harness under the dash and next to the steering column, etc. The flasher unit can be a very difficult item to find without the aid of a service manual.

The flasher unit is made up of a stationary contact and a movable contact mounted on an expansion strip. In their normal at-rest position, the contacts are closed. When a turn is selected, current flows through the expansion strip and the contacts to feed the rest of the circuit. The expansion strip, sensitive to the current flow, heats up and opens the points. With the circuit open, the expansion strip cools and snaps back to its normal position. The contacts are closed again and the cycle is ready to repeat itself.

The thermal cycling of the expansion strip produces an audible metallic clicking noise which serves as an additional indicator that the turn signal system is working.

Flashers are designed and calibrated to flash a definate number of bulbs; this number varies in different car models and body styles. The correct flash rate of any turn signal system can be upset by a simple misapplication of a flasher unit. Flasher units may have different calibrations, but they all can plug into any turn signal circuit. Therefore when you replace a flasher, make sure that it matches the lamp load.

Flasher Identification Chart

No. Of Bulbs At Rear Of Car	Flasher No.
1. One bulb per side	1. Tung-Sol 223 or Signal Stat 147
2. Two bulbs per side	2. Tung-Sol 322
3. Three bulbs per side	3. Signal Stat 148

NOTE: Hazard warning light flashers are interchangeable Tung-Sol 552 or Signal Stat 175.

Another factor that can upset the flash rate is the misapplication of turn signal bulbs. Turn signal systems are designed to use either 1034 or 1157 bulbs. Both bulbs produce the same candlepower, and can plug into the same socket holders, but the 1157 bulb draws more current. The use of 1034 bulbs in place of 1157 bulbs will slow the flash rate or even stop it completely; the use of 1157 bulbs in place of 1034 bulbs will speed up the flash rate and shorten flasher life.

A heavy- duty flasher (variable-load type) is available to flash any number of bulbs. It will always flash at the same rate, even if a bulb burns out. Heavy-duty flashers are used when the car has a trailer-towing package; otherwise, the standard flasher would not be able to withstand the extra current load. The disadvantage of a heavy duty flasher is that it gives no indication to the driver that a bulb is burned out.

The operation of the variable-load type flasher is discussed in more detail under "Hazard Warning Lights." A hazard-warning-light flasher can be used in the turn signals for heavy-duty service.

Hazard Warning Flasher

Unlike the standard turn signal flasher, the hazard warning flasher is a variable-load unit and will operate regardless of the number of bulbs that are burned out. It also continues to flash reliably as the battery voltage decreases during a long disablement. Common practice is to locate the flasher on the fuse block or on the safety panel above the glove box as found on some vehicles. In outward appearance, the flasher is identical to the turn signal flasher.

The variable-load flasher action starts with its contact points normally open. This means that when the hzaard warning switch is turned on, there is a slight delay before the lights come on and begin to flash.

The flasher is a thermally actuated unit made up of a stationary contact, a movable contact mounted on an expansion strip, and a heating coil.

Electrical Competencies- Body & Chassis

No. F12 Identify and Diagnose Typical Turn Signal, Hazard, Warning, Stop Light, and Cornering Light Circuits

When the switch is closed, the coil is in series with the bulbs. The high resistance of the coil, however, prevents the bulbs from lighting. The coil heats up and the thermal action on the expansion strip closes the contacts. With the contacts together, there is a parallel circuit in the flasher. Since current prefers to follwo the path of least resistance, it flows through the contacts to light the bulbs. At this time there is very little current flow through the coil, and the expansion strip is allowed to cool and contract, opening the points. The current again flows through the coil to start the cycle over.

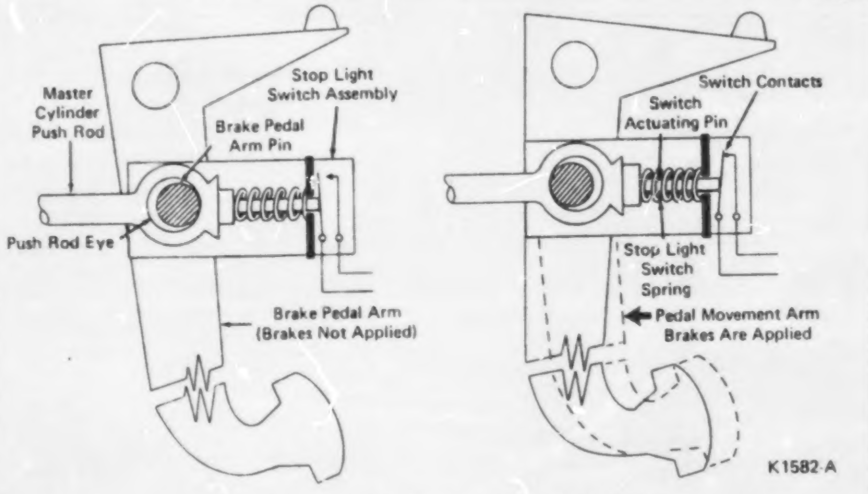
Condition	Possible Cause	Connection
Dead Circuit	1. Blown fuse	1. Locate fuse block, replace blown fuses.
	2. Defective flasher	1. Refer to flasher application chart and replace
Flash rate too slow	1. Defective flasher	1. Refer to flasher application chart and replace
	2. Wrong flasher application: a three-signal-light flasher in place of a two-signal light flasher, etc.	1. Check flasher application chart and replace if necessary.
	3. Wrong light bulb application; a 1034 in place of a 1157 bulb. The flasher action may even stop.	1. Locate lamp application chart; replace with correct bulb.
	4. Poor ground at one of the lamps.	1. Clean connections; repair or reconnect around wire.
Flash rate too fast	1. Wrong flasher application: a two signal light flasher in place of a three signal light flasher.	1. Check flasher application chart and replace if necessary.
	2. Wrong light bulb application: a 1157 bulb in place of a 1034 bulb.	1. Locate lamp application chart, replace with correct bulb.
	3. Extra lights in the circuit, such as trailer lights.	1. Replace flasher unit with heavy-duty flasher.
	4. High voltage.	1. Test for problems in charging system.
Live Circuit, no flasher action	1. Burned-out light bulb.	1. Locate and replace burned-out bulb.
	2. Wrong light bulb application; a 1034 bulb in place of a 1157 bulb.	1. Check with bulb application chart before replacing.
	3. Defective flasher; both sides not flashing.	1. Locate flasher and replace.
	4. Poor light bulb grounds	1. Clean connections to assure good contact.

Stop Lights

The stop light was probably the first signaling device used on the automobile. It provides a steady bright light to the rear of the vehicle to indicate that the operator intends to stop the vehicle or slow the speed by braking.

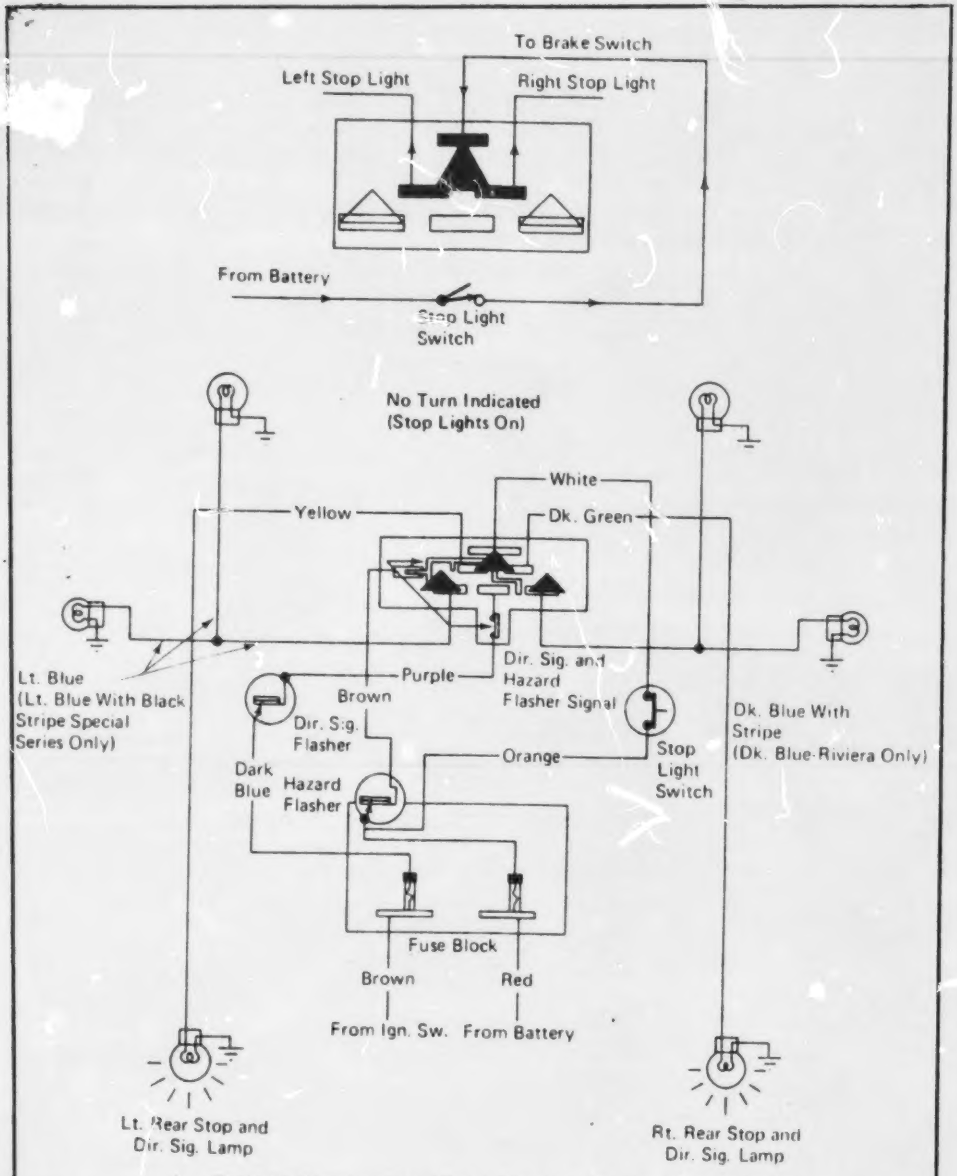
Present stop light circuits employ at least two lights. The stop lights are controlled by a mechanical switch mounted on the brake pedal bracket. When the switch is activated by the brake pedal, the circuit is completed through the turn signal switch and high-current filament in the taillight bulbs; dual filament bulbs with trade numbers 1157 or 1034 are used. The same high-current filaments in the taillight bulbs are also employed as the light source for the turn signal and hazard warning circuits. How these three circuits work together will be discussed in detail, later in this chapter, in the sections "Turn Signals" and "Hazard Warning Lights."

On older vehicles the brake light switch is generally located in the brake line at the master cylinder and is activated by hydraulic pressure build-up when the brakes are applied.


Master Cylinder Push Rod
Stop Light Switch Assembly
Brake Pedal Arm Pin
Push Rod Eye
Brake Pedal Arm (Brakes Not Applied)
Switch Contacts
Switch Actuating Pin
Stop Light Switch Spring
Pedal Movement Arm Brakes Are Applied
K1582-A

Courtesy of Ford Customer Service Division.
67966 Ford Mercury
67970 Comet-Falcon-etc.

No. F12 Identify and Diagnose Typical Turn Signal,
Hazard, Warning, Stop Light, and
Cornering Light Circuits


To Brake Switch
Left Stop Light
Right Stop Light
From Battery
Stop Light Switch
No Turn Indicated (Stop Lights On)
White
Yellow
Dk. Green
Lt. Blue (Lt. Blue With Black Stripe Special Series Only)
Purple
Brown
Dir. Sig. and Hazard Flasher Signal
Dir. Sig. Flasher
Dark Blue
Hazard Flasher
Orange
Stop Light Switch
Dk. Blue With Stripe (Dk. Blue-Riviera Only)
Fuse Block
Brown
Red
From Ign. Sw.
From Battery
Lt. Rear Stop and Dir. Sig. Lamp
Rt. Rear Stop and Dir. Sig. Lamp

Brake lights *(Courtesy of Buick Division of General Motors Corp.)*

Stop Lights	Possible Cause	Correction
One bulb inoperative	1. Bulb burnt out.	1. Replace bulb.
One side inoperative	1. Loose connection, open wiring or defective bulbs.	1. Turn on directional signal. If lamp does not operate, check bulbs. If bulbs are OK, secure all connections. If lamp still does not operate, use test lamp and check for open wiring.

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Hazard, Warning, Stop Light, and
Cornering Light Circuits

Condition	Possible Cause	Correction
	2. Defective directional signal switch or cancelling cam .	1. If lamp will operate by turning directional signal on, the switch is not centering properly during cancelling operation. Replace defective cancelling cam or directional signal switch.
All inoperative	1. Stop-hazard fuse blown.	1. Replace fuse. If new fuse blows, repair short to ground in circuit between fuse and lamps.
	2. Stop-switch misadjusted or defective.	1. With brake pedal depressed check white wire terminal in steering column connector with test lamp. If lamp does not light, check stop switch for proper adjustment. If adjustment is OK, replace stop switch.
Will not turn off	1. Stop switch misadjusted or defective.	1. Readjust switch. If switch still malfunctions, replace.

Cornerning Lamps

Cornering lamps are steadily burning lamps used in conjunction with the turn signal system to supplement the headlamps by providing additional illumination in the direction of turn. They make the car more visible to other drivers approaching from the side and also improve the visibility of nearby objects not illuminated by the headlights during the turn. These lamps are mounted, one on each side, in the forward position of the front fenders.

Cars with cornering lamps require a different turn signal switch which provides an additional set of switching contacts for the cornering circuit only. When either the parking lights or the headlights are on, moving the turn signal level for a left or right turn also causes a cornering light to come on in the direction of the turn. Since thereis no circuit flasher, the light does not blink and remains on until the turn is cancelled.

The cornering light circuit shares a common point with the taillight circuit and is protected by the taillight circuit fuse. Cornering lights are usually an optional equipment item on large-size cars.

Electrical Competencies- Body & Chassis

No. F12 Identify and Diagnose Typical Turn Signal, Hazard, Warning, Stop Light, and Cornering Light Circuits

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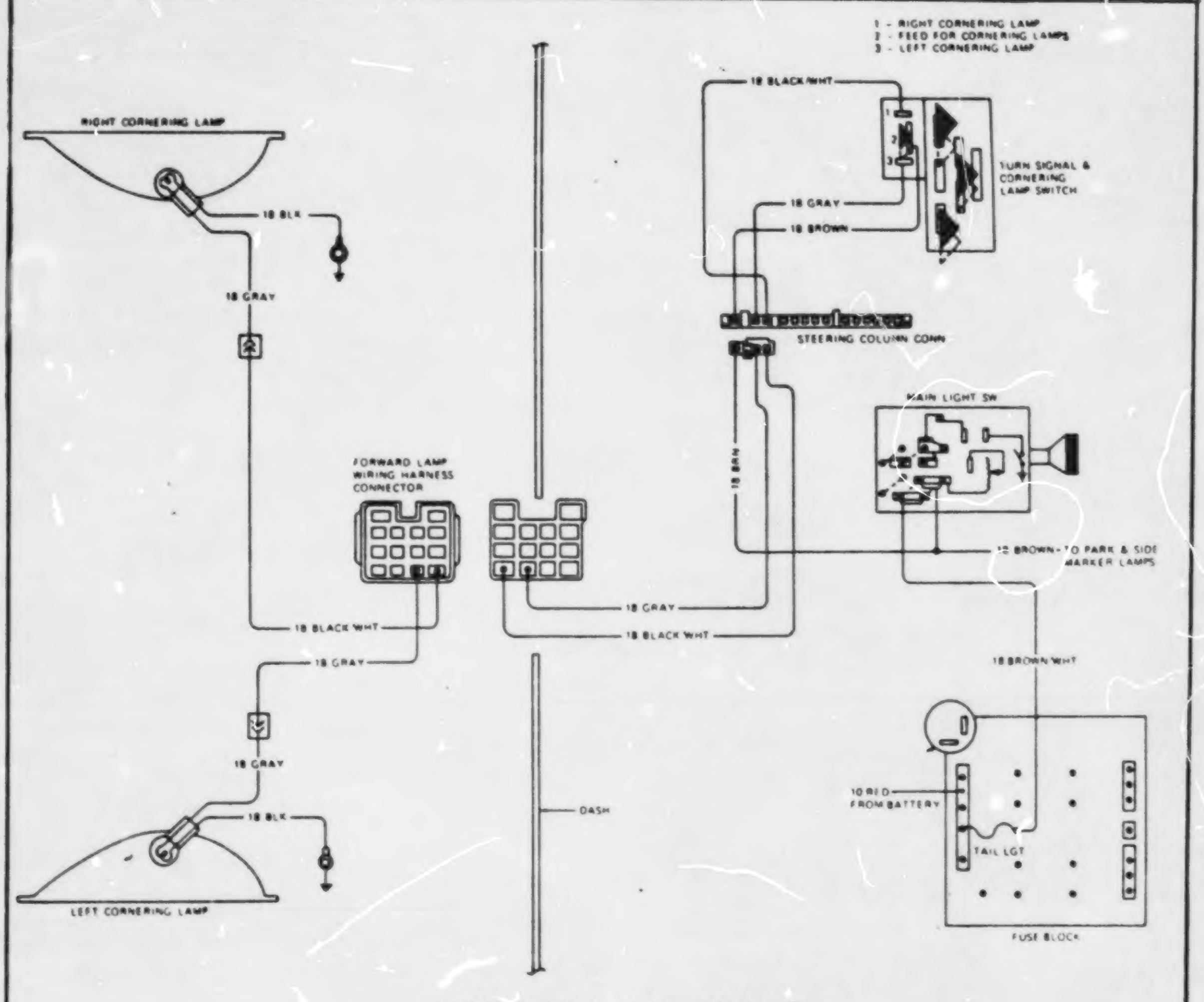

1 - RIGHT CORNERING LAMP
2 - FEED FOR CORNERING LAMPS
3 - LEFT CORNERING LAMP
RIGHT CORNERING LAMP
18 BLK
18 GRAY
18 BLACK/WHT
TURN SIGNAL & CORNERING LAMP SWITCH
18 GRAY
18 BROWN
STEERING COLUMN CONN
MAIN LIGHT SW
18 BRN
FORWARD LAMP WIRING HARNESS CONNECTOR
18 BROWN - TO PARK & SIDE MARKER LAMPS
18 GRAY
18 BLACK WHT
18 BLACK WHT
18 GRAY
18 BROWN WHT
18 GRAY
10 RED FROM BATTERY
18 BLK
DASH
TAIL LGT
LEFT CORNERING LAMP
FUSE BLOCK

Buick Motor Division of General Motors Corp.

Cornering Lamp	Possible Cause	Correction
One lamp inoperative	1. Loose connection.	1. Secure connector near lamp
	2. Burnt out bulb.	1. Replace burnt out bulb.
	3. Open ground connection	1. If bulb is known good and test lamp lights at connector near lamp, repair open ground connection.
	4. Open in wiring.	1. If test lamp lights on both sides of steering column connector, repair open wiring between connector and lamps. If not, check for open connection in connector.

Condition	Possible Cause	Connection
	5. Defective turn signal switch.	1. If test lamp lights at brown wire terminals of steering column connector, but not at gray or black/white strip wire terminals, replace turn signal switch.
Both lamps inoperative	1. Blown tail light fuse	1. If tail lamps to not light, replace tail light fuse if blown. If new fuse blows, repair short to ground between fuse and lamps.
	2. Loose connection.	1. Secure all connectors at light switch and steering column.
	3. Open in wiring.	1. If tail lamps light, check brown wire at steering column connector with test lamp. If test lamp lights on lamp side of connector only, repair terminal. If tail lamps do not light, check for open wiring between light switch and battery.
	4. Defective turn signal switch.	1. If tail lamps light and test lamp lights on both sides of steering column connector, replace turn signal switch.
	5. Defective light switch	1. If tail lamps do not light and test lamp lights at light switch terminal No. 5 but not at No. 4, replace light switch.

AUTO MECHANICS

Electrical Competencies - Body & Chassis

No. F-13 Identify and Diagnosis Typical
Dome and Convenience Lighting Circuits

OBJECTIVE:

Upon completion of the following material you will be able to diagnosis and identify typical dome and convenience light circuit malfunction.

EXPLANATION:

This will involve the tracing down of the dome and convenience light circuits using a wiring diagram, and diagnosing any problems.

MATERIALS NEEDED:

Manufactures wiring diagrams

TOOLS NEEDED:

Common electrical test equipment

References	Do
#1. --	#1. Study assigned references.
#2. Ch. 4, p. 84-84 Ch. 5, p. 105 Ch. 6, p. 121 Ch. 19, p. 398-401	#2. Study Information Sheets.
#3. p. 442-451 p. 464-473 p. 690-708	#3. Identify and diagnose lighting malfunctions on a live vehicle.
#4. p. 427-436 p. 462-466 p. 291-292	
#5. Ch. 32, p. 522-535	
#6. Ch. 34, p. 322-333 Ch. 60, p. 598-610	
#7. Ch. 23, p. 287-297	
#8. Ch. 8, p. 178-217	

No. F-13 Identify and Diagnose Typical Dome and
Convenience Lighting Circuits

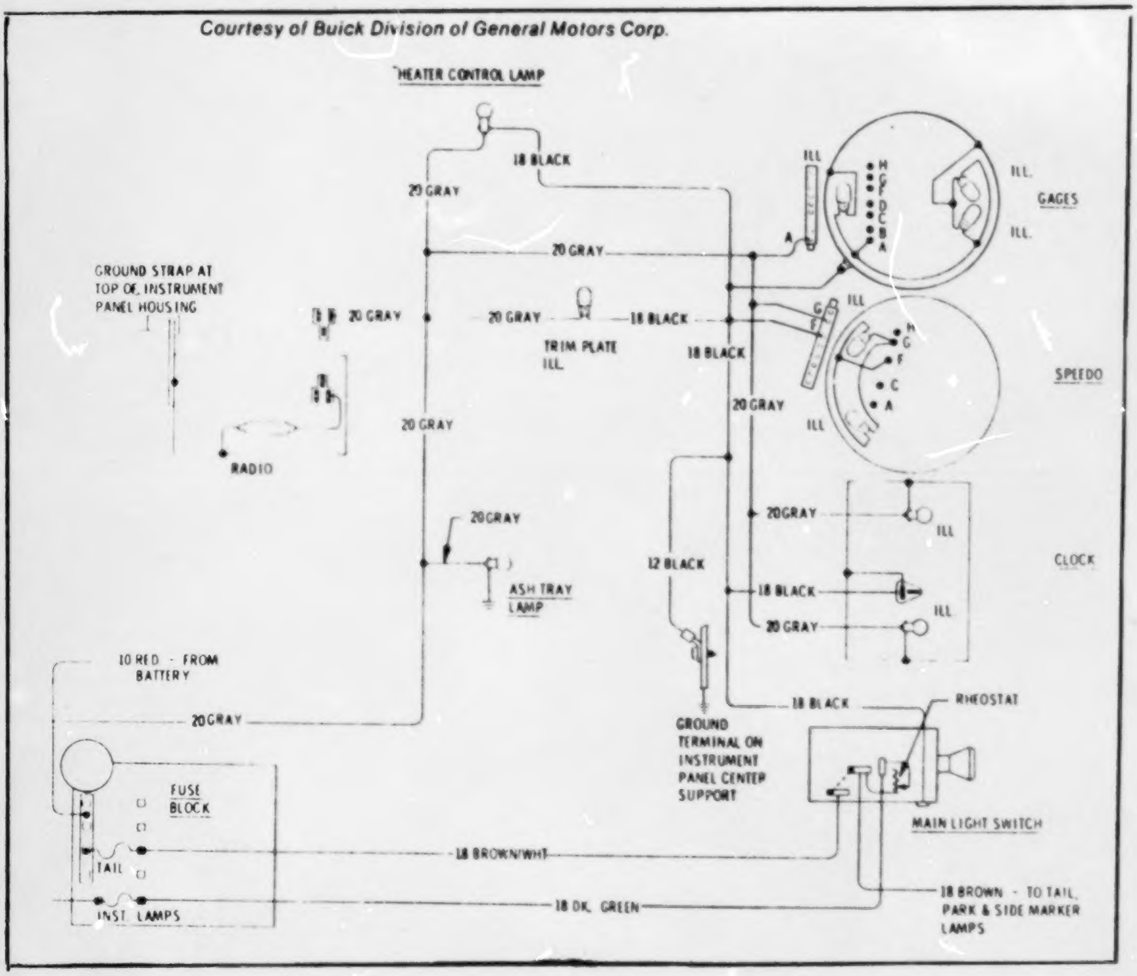
Information Sheet #1

Instrument Panel Lights

The instrument panel lights provide indirect lighting to illuminate the speedometer, instrument gauges, heat-defroster controls, air-contidioner controls, ash tray, clock, and transmission control dial.

The instrument panel lights are controlled by the headlight switch, which incorporates a knob-operated rotating rheostat to adjust the light brightness. The circuits are protected by a fuse (generally 4 amps).

Using the diagram below, we can trace the instrument panel light circuit.


HEATER CONTROL LAMP
18 BLACK
20 GRAY
20 GRAY
ILL
ILL.
GAGES
ILL.
A
H
G
F
E
D
C
B
A
GROUND STRAP AT TOP OF INSTRUMENT PANEL HOUSING
20 GRAY
20 GRAY
TRIM PLATE ILL.
18 BLACK
18 BLACK
G
F
ILL
H
G
F
C
A
SPEEDO
ILL
20 GRAY
20 GRAY
RADIO
20 GRAY
ASH TRAY LAMP
12 BLACK
20 GRAY
ILL
18 BLACK
CLOCK
20 GRAY
ILL
10 RED - FROM BATTERY
20 GRAY
18 BLACK
RHEOSTAT
GROUND TERMINAL ON INSTRUMENT PANEL CENTER SUPPORT
FUSE BLOCK
MAIN LIGHT SWITCH
TAIL
18 BROWN/WHT
INST. LAMPS
18 DK. GREEN
18 BROWN - TO TAIL, PARK & SIDE MARKER LAMPS

Courtesy of Buick Division of General Motors Corp.

Starting with the taillight fuse, power enters into the headlight switch to a common point shared by both the taillight and instrument panel light circuits. Since the common point acts as the power pick-up for the instrument panel lights, the power flow will pass through the headlight switch rheostat and to the fuse block, where the circuit is fused and power is passed on to the lights.

From the above discussion it should be obvious that perfectly working instrument panel lights won't work if the taillight fuse is blown.

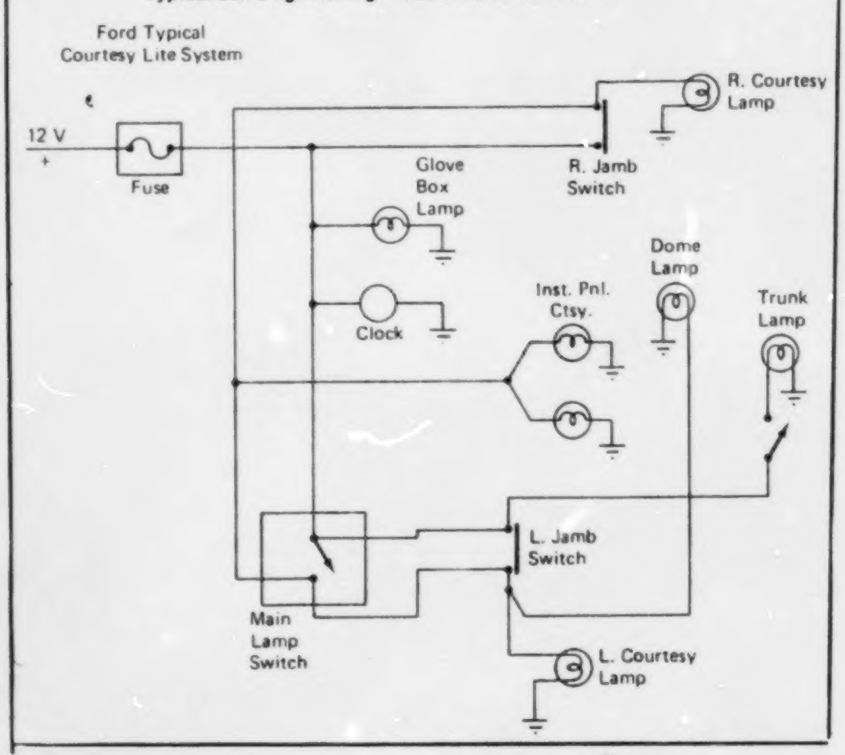
On some Chrysler cars using a throw-type headlight switch, a separate instrument panel dimmer switch is mounted on the dash. The circuit, however, remains basically the same.

Courtesy Lights

Courtesy lights illuminate the floor area of the automobile when the doors are open. They operate, along with the dome light, from the headlight switch and/or from a door jamb switch. It is not uncommon to find the courtesy, dome, trunk, and glove box lights linked to the same fuse for power and circuit protection. Additional items that can be found on the same fuse hook-up are power feeds to the clock and cigar lighter.

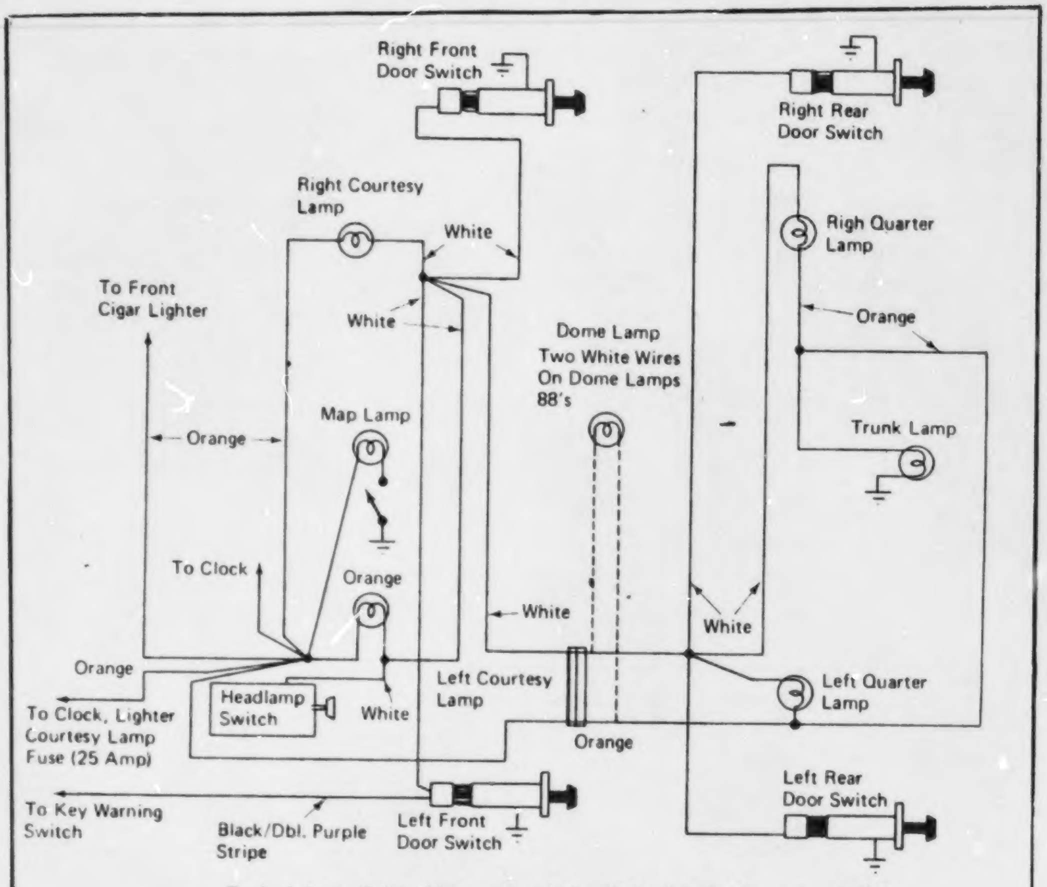
There are two types of courtesy light circuits. A good way to remember them is to call them the "hot switch circuit" and the "ground switch circuit". In the hot switch circuit, the switches are all insulated and are used as the power relay to the lights. In the ground switch circuit, the switches serve as the grounding media for the lights. These circuit types are shown in Figs. 8-39 and 8-40. Generally, Ford Motor Company vehicles use a hot switch circuit, and American Motors, Chrysler, and General Motors use a ground switch circuit.

Typical dome light wiring—insulated switch circuit.


Ford Typical
Courtesy Lite System
12 V
+
Fuse
R. Courtesy Lamp
R. Jamb Switch
Glove Box Lamp
Clock
Dome Lamp
Inst. Pnl. Ctsy.
Trunk Lamp
L. Jamb Switch
Main Lamp Switch
L. Courtesy Lamp

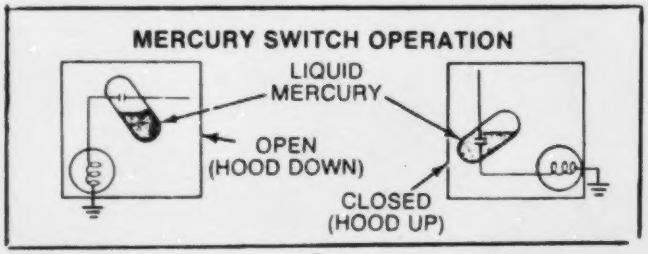
Electrical Competencies- Body & Chassis

No. F-13 Identify and Diagnose Typical Dome and
Convenience Lighting Circuits


Right Front
Door Switch
Right Rear
Door Switch
Right Courtesy
Lamp
White
Righ Quarter
Lamp
To Front
Cigar Lighter
White
Orange
Dome Lamp
Two White Wires
On Dome Lamps
88's
Map Lamp
Trunk Lamp
Orange
To Clock
Orange
White
White
Orange
Headlamp
Switch
White
Left Courtesy
Lamp
Left Quarter
Lamp
To Clock, Lighter
Courtesy Lamp
Fuse (25 Amp)
Orange
Left Rear
Door Switch
To Key Warning
Switch
Black/Dbl. Purple
Stripe
Left Front
Door Switch

Typical dome light wiring—grounded switch circuit. *(Courtesy of Oldsmobile Division of General Motors Corp.)*

There is also another type of switch used by virtually all of the car manufacturers. Its a mercury operated switch that grounded through the bulb, and is generally used on most hoods and trunk lids. This switch is made up of a small capsule of mercury with two wires meeting at one end. When the hood is opened the mercury runs to the opposite end of the capsule and completes the connection causing the light to go on.


MERCURY SWITCH OPERATION
LIQUID
MERCURY
OPEN
(HOOD DOWN)
CLOSED
(HOOD UP)

INSTRUMENT PANEL AND COURTESY LIGHTS

Condition	Possible Cause	Correction
Courtesy Lights Inoperative	1. Blown fuse	1. Locate and repair short to ground.
	2. Burnt out bulbs	1. Refer to bulb application chart and replace.
	3. Defective light switch.	1. Replace
	4. Open ground connections (switch or bulb)	1. Turn lights on, check circuit, a lamp socket and switch. Repair open ground connection.
	5. High Resistance	1. Clean or replace connections and sockets.